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ELEKTOR ELECTRONICS

THE INTERNATIONAL ELECTRONICS MAGAZINE

COPYBIT ELIMINATOR

24 cm ATV transmitter

LCD displays

Build your own toroid core inductors and RF transformers

Mini preamplifier

Bi-directional RS232-Centronics converter







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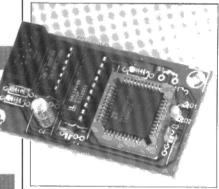
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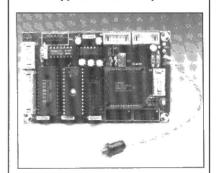
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An inexpensive and straightforward circuit for eliminating the copybit from a digital S/PDIF audio signal is described on p.30. It enables any existing or future digital audio source to be copied digitally time after time after time to any other digital audio recording system. It is, of course, intended solely for the digital recording and processing of one's private musical work.

Front cover

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ALL GAS AND VAPOUR

The development of gas-filled valves

By Gregor M.R. Grant

century ago this year, two British scientists, Athe physicist Lord Rayleigh and the chemist Sir William Ramsay, announced their discovery of the gas argon. In the following year, Ramsay confirmed the existence of helium on earth and, over the next four years with the assistance of the chemist Morris Travers, successfully unveiled the remaining inert gases in the atmosphere: neon, krypton and xenon.

At the century's close, another Briton, the meteorological physicist C.T.R. Wilson, showed that electricity could flow in a gas. Thus, the groundwork was laid for a new branch of the electrical industry: the technology of gas-filled valves.

In 1901, the American inventor Peter Cooper-Hewitt produced a mercury vapour lamp and nine years later the French scientist George Claude developed glass tubes containing a neon-helium mixture. They were some 38 ft (11.58 m) long and the prototypes of the near-infinite variety of such tubes that colour our lives today.

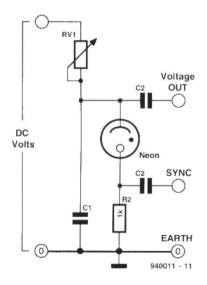


Fig. 1. A simple neon time-base circuit.

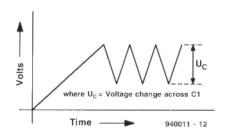


Fig. 2. Time-base voltage amplitude of Fig. 1.

Gas tubes therefore are electron tubes containing vapour or gas at low pressure in which an electric discharge takes place. There are two general types. Firstly, the cold cathode tube in which a glow disbetween the electrodes. These tubes have a high voltage drop and low current. Hot cathode tubes on the other hand operate on the principle of an arc discharge conducting a current. They have a low voltage drop and a high current.

By 1914, the American physicist Irving Langmuir began to take an interest in the development of gas-filled, tungsten-filament lamps. The filaments he used were coiled and the space around them contained some mercury, which was allowed to condense and then return to the filament area. Fed from a 110-volt source via a series resistor, they enabled Longmuir and his team to look into the lamp's operation at high temperature. One early observation was that, during the many burn-outs, an arc was created at the filament breakpoint. In the course of these trials, Langmuir became the first scientist or engineer to show '... how a grid voltage could be used to control the starting of the main arc.' In fact, one of Langmuir's team sketched a glass tube with a hot filament, separate anode and liquid mercury cathode, thus anticipating the mercury arc rectifier.

charge serves to maintain a conducting path

The neon tube and the thyratron

By 1922, the British radio engineer R.St.G. Anson developed the relay named after him in which '... a neon tube was used for signal-shaping in telegraph circuits."2

Neon is, of course, one of the two most commonly used inert gases, the other being argon. Industrially, argon is the more often used of the two, largely because the only commercial source of neon is the earth's atmosphere. Indeed, where would our profession be without either argon or - above all - neon?

The neon tube is simply a diode valve filled with low pressure neon gas. Neither of the electrodes is heated, but when a potential is applied across them the gas ionizes. The magnitude of the potential, known as the striking voltage, depends on the gas pressure, the material used for the electrodes, and the surface condition and the distance between the electrodes.

For neon, the striking voltage is around 130 V. When this potential falls to about 100 V, however, the gas deionizes. This became the basis of the early time-base circuits. A simple neon time-base is shown in Fig. 1. Capacitor C₁ charges up through variable resistor RV1 and is discharged through the noon tube when the charge equals the tube's striking voltage. Thus, the time base voltage amplitude is the difference between the ionizing and deionizing levels, that is, around 30 V. This is shown in Fig. 2.

The time base and the voltage under investigation can be synchronized by applying the voltage across R2 in series with the neon tube. In other words, a time base is an electronic sun dial which, if combined with a delineating device, gives a graphical indication of electrical phenomena. One such device is the oscilloscope; another, the digital signal analyser.

By 1928, however, the time base was still an unsatisfactory circuit since its output voltage, and hence the amount of deflection it could provide, was small. Matters improved immediately, however, with the introduction of the gas-filled valve, or thyratron. Its creator, Albert W. Hull, was a versatile and unusual man. He had originally graduated in Greek from Yale and taught languages for a few years before returning to his alma mater to study physics. In 1921, he published a brilliant paper on electron movement between two cylindrical structures in a magnetic field, which configuration he termed a magnetron!

It was at this time, too, that he joined the General Electric Corporation's research laboraroty at Schenectady, New York. Here, he followed his earlier work with a paper on

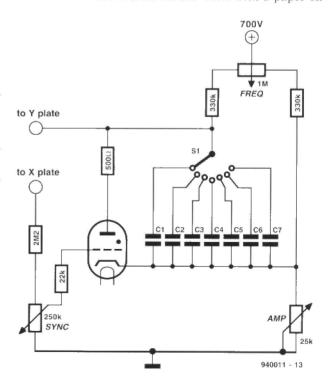


Fig. 3. An AF and low-RF time-base circuit employing a thyratron.

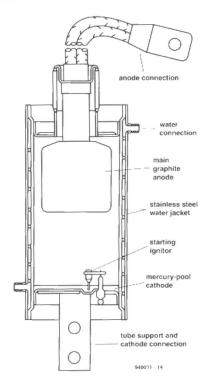


Fig. 4. A typical sealed ignatron.

'Hot Cathode Thyratrons' in 1928, announcing the device itself and, in 1933, his masterpiece, 'Thyratrons'.

Basically, the device was a thermionic valve '... filled at very low pressure with mercury vapour or one of the inert gases ... the characteristics of the valves being to some extent influenced by the particular gas filling.'3 These devices gave renewed impetus to the use of the cathode ray oscilloscope as an investigative tool '... because they pass negligible current until a certain voltage ... is reached, when they suddenly conduct very freely, indeed'4, discharging a capacitor with considerable speed, thus producing a rapid flyback. This last was the result of '...an increase in the separation between the **strik**-

ing and extinction potentials.'5

Shortly after the thyratron's introduction, the leading engineers of the day, among them Alan Blumlein, designed time-base circuits around it. Blumlein's 1932 Britishpatented design used a large inductor in the charging circuit to improve charge linearity.

The frequency range of the thyratron, however, was not all that extensive and they proved, ultimately, to be less effective as time-base generators than hard valves, firstly because of their relatively short life, and secondly because of their inconsistent characteristics.

Blumlein was the man who first used the **Miller effect** of a triode valve to create the first truly linear time base. He developed it in the early 1940s whilst working on an airborne radar system and termed it the **Miller integrator**.

Another serious limitation of thyratron-based time-base circuits was their recovery time from the flyback condition. This took '... a serious fraction of the cycle at a few tens of kHz'6 and so limited their effective frequency range. In fact, by the late 1950s thyratrons were no longer used in commercial oscilloscopes. **Figure 3** is a good example of a thyratron-based time-base circuit.

The ignatron

In 1933, the Westinghouse Corporation announced their latest development, the **ignatron**, whose general construction is shown in **Fig. 4**. A pool of mercury serves as the cathode. Its potential was quickly appreciated and by the end of the following year a welding control system using such devices was in commercial operation in the USA.

In welding operations the ignatron acts '... as a special form of timing switch, enabling a current to pass through the metal junction for a specified and controlled period."

The ignatron combines many of the features of the mercury arc rectifier with those

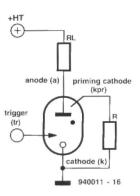
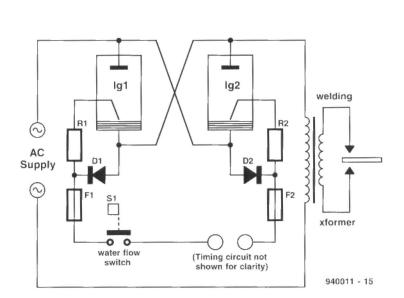


Fig. 6. Circuit operation of the Z700U cold cathode trigger tube.

of the thyratron. Like the latter, the ignatron has a low arc voltage drop, but one combined with a far larger current than can be achieved with a thermal cathode of the type used in a thyratron.

In the welding circuit of Fig. 5, both ignatrons and their protective resistances are shunted by metal rectifiers to prevent reverse current passing through them. At switch-on, ignatron 1 anode is positive. Consequently, current flows from the anode to the cathode of ignatron 2, where it divides, the larger part passing through rectifier D2, the remainder flowing through Ig_2 and R_2 as reverse current. The major portion then continues through fuse F2, the timing circuit, the water-flow switch and fuse F1, where it again divides, the larger part passing through R1 and the ignatron igniter. Thus, Ig1's igniter handles a large current pulse which fires the main discharge. Immediately the discharge is set up, the igniter is short-circuited, so that its current is zero.

With the anode of \lg_2 positive, the circuit action is as before, but in the opposite direction. Consequently, each device fires in turn as long as the control circuit is closed. Large current pulses, alternating in direction, flow



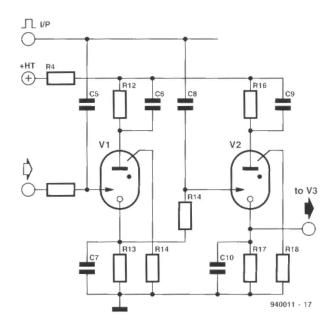


Fig. 5. Ignatron circuit as used in spot welding.

Fig. 7. Part of the ring counter circuit of an early computer.

through the welding transformer primary. inducing even larger ones in the secondary.

The circuit is a typical example of a nonsynchronous arrangement used in both spot and projection welding.

The cold cathode trigger tube

In 1936, the Bell Telephone Laboratories announced their latest development, the cold cathode trigger tube, an invention of research engineer S.B. Ingram. A later example of the device, the Z700U, is shown in Fig. 6.

The voltage applied between the anode and cathode is some 200 V. The priming cathode, located behind the anode, is connected to the negative line via current-limiting resistor R. Since the physical gap between the priming cathode and the anode is small. breakdown occurs and a current-limiting discharge develops. Consequently, limited ionization takes place.

The trigger electrode is now made positive with respect to the cathode, causing a discharge across the cathode-trigger gap. This, in turn, increases the ionization, which reduces the anode-cathode gap striking voltage. The anode-cathode gap breaks down, but the discharge within it is maintained. The anode current is limited by $R_{\rm L}$, and the cathode-anode voltage remains constant at the tube's maintaining voltage.

When the tube conducts, the trigger is redundant. The tube's glow, therefore, can be extinguished in only two ways: firstly, by reducing the anode current, and secondly by bringing the anode voltage below the maintaining voltage. As can be seen, the device has some facets in common with both the thyratron and the ignatron.

Known as grid glow tubes in the UK, they were little used prior to the second world war. Once hostilities had broken out. however, the demand for triggering devices for proximity fuses for bombs, torpedoes, and the like, increased almost exponentially. The cold cathode trigger came into its own. Later, when hostilities had ceased, the tube found another role. It was frequently used in the ring counter circuits in early computers, an example of which is shown in Fig. 7.

By the middle of the 1950s, the first commercial thyristor or silicon-controlled rectifier (SCR) was developed by the General Electric Corporation. A decade later it had eclipsed soft valves in many power control applications. Nevertheless, gas-filled valves continue to be used in the very-high-power field.

Currently, the choice of gas depends on the hold-off voltage, current handling and rate of rise of current or turn-on time. Mercury and xenon, for example, are used where high currents are a priority, and hydrogen is the preferred gas for high-voltage applications. Hydrogen thyratrons, in fact, operate at gas pressures of between 300 and 900 millibar and have very rapid turn-on times. They can handle stand-off voltages of 50 kV and peak currents of around 5 kA. Among their many applications is high-power laser switch-

Of course, neon, the original soft-valve gas, is still very much with us, its orange-red glow indicating all manner of reassuring parameters from heartbeats to hertzs, Classic FM* to miles per hour.

In their centenary year, however, the inert gases are facing their greatest challenge: semiconductors. SCRs, LCDs and microscopic laser devices already indicate the way ahead. By the turn of the century, soft valves may have joined their hard counterparts as interesting relics of a past technology.

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- 5. Ibid Ref. 2, p. 19.
- 6. Ibid Ref. 4, p. 161.
- 7. Ibid Ref. 3, p. 151.
- Classic FM is a chain of radio stations in the UK, broadcasting classical music 24 hours per day, seven days a week.

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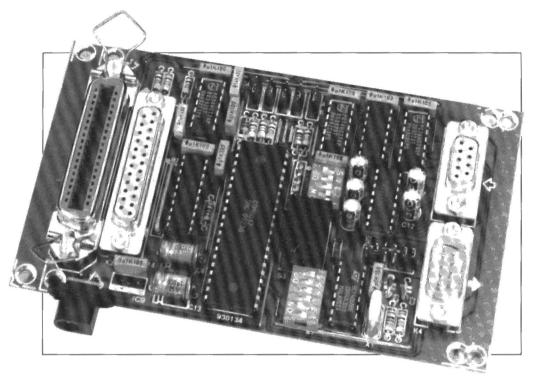
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BIDIRECTIONAL RS232-TO-CENTRONICS CONVERTER



The link between a PC and its peripherals is usually either parallel (Centronics) or serial (RS232). In some cases, however, it is necessary to connect the PC's parallel port to a peripheral with a serial input, or the other way around (serial output to parallel input). No problem with the data format converter described here.

Design by A. Rietjens

DMITTEDLY the demand for paral-Alel-to-serial converters is not as high as it used to be, now that PCs are equipped with a host of peripheral connection options. None the less, there are occasions when such a converter is very useful. Take, for example, the following situation: you are using a number of programs that default to the first Centronics port to produce hard copy, while printer port redirection using the MODE command is either not supported, or difficult to achieve. Unfortunately, the printer is in the room next door, and the distance is such that serial communication is likely to be more reliable than parallel communication. Another example would be a printer with a Centronics input only, which you would like to connect to a serial cable.

The converter described here can work in two directions: parallel to serial, or serial to parallel. Unfortunately,

these conversions can not operate simultaneously, but that will rarely cause problems.

Block diagrams

Since the present circuit is bidirectional (the direction being set with the aid of jumpers), it is appropriate to give separate block diagrams for the two directions of conversion. These diagrams are shown in **Fig. 1**.

Before describing the general structure of the circuit, a short discussion on the protocols drawn up for communication via the Centronics and the RS232 ports on a PC. The Centronics standard is based on eight databits which are conveyed in parallel. The sending device signals the presence of valid and stable data by pulling the STROBE line logic low. The receiving device has two ways of signalling its state. By transmitting a BUSY signal,

it can inform the sending device that it is busy, and can not handle new data at that particular moment. The acknowledge signal, which is active low, and usually appears at the end of the BUSY signal, is sent by the receiving device to signal that a databyte has been received correctly for processing. Since BUSY and ACKNOWLEDGE have roughly the same function, many printers supply a BUSY signal only (although an ACK connection is available as a secondary function).

An RS232 link has a serial data input and output at both ends. In addition to data lines, it has several control lines, which allow a number of different modes of communication (handshaking) to be implemented between two devices. One of these is the XON/OFF handshaking protocol, when the receiver transmits a certain character via the serial data line to tell the sending device to continue or stop transmitting data. Most printers, however, employ hardware handshaking. A line called DTR (data terminal ready) is actuated by the printer to signal that it is ready to receive data. Since the transmission of serial bits is stopped as soon as DTR is de-actuated, the function of this line may be compared with that of BUSY on the Centronics port. Another possibility is the RTS (request to send) line. An active level on this line indicates that the receiver wants to receive data, or is ready to do

Armed with a basic knowledge about the function of the main signals we can start to examine the operation of the converter circuit. Referring to Fig. 1a, when parallel-to-serial conversion is used, data enters the circuit via the Centronics converter, and is stored in a buffer (actually a latch) under the control of the STROBE signal furnished by the sending device. A special integrated circuit which contains a parallel-to-serial converter and a latch ensures that the eight received data bits are shifted sequentially, in the correct order. The sequence of eight data bits is preceded by a start bit, and followed by a stop and/or a parity bit. The block marked 'handshake' arranges the communication between the two sides. The busy and acknowledge signals needed for this purpose are derived from the DTR or the RTS control signal supplied by the RS232 sending device. The selection

between DTR and RTS is made by the user.

The diagram of the serial to parallel converter (Fig. 1b) is virtually the mirror image of its parallel-to-serial counterpart. Serial data arriving at the circuit are converted into parallel, with the converter using the CTS (clear to send) line to signal to the sending device that bits may be transmitted. When a complete serial word is received, the seven or eight databits contained therein are conveyed, in parallel, to a latch. Next, a strobe pulse is issued to tell the equipment connected to the Centronics output that valid and stable data are available for copying. At the same time, the handshake logic looks at the state of the BUSY line, to see if new data may be transmitted. Figure 1b also shows feedback between the converter's output and input. This has been added because many RS232 ICs in PCs appear to have a buffer of two bytes. This means that the transmission of the current byte is not stopped immediately on receipt of a 'halt' condition, but the buffer is cleared first. Consequently, the converter receives another byte, although it has told the sending device to stop transmitting. This extra byte has to be stored, because the Centronics device is not (yet) ready to accept it. The feedback causes the extra byte to circulate in the converter until the Centronics bus is freed again.

So far, so good. Although the blocks in the diagrams in **Fig. 1** would appear to cover all function of the circuit, the handshake signals do require a couple of discrete gates and bistables to be added.

Circuit description

The heart of the circuit shown in Fig. 2 is the Type COM8017 UART (universal asynchronous receiver/ transmitter), which is a follow-up type of the now obsolete AY-3-105D. The COM8017 arranges the conversion from parallel to serial and vice versa. These operations run under the control of a clock signal supplied by IC2, a CD4060. The clock generator/divider uses a 2.4576-MHz quartz crystal. The dividers contained in the CD4060 provide the TCP and RCP (transmitter and receiver clock) signals for the UART. The frequency of these signals must equal 16 times the desired baud rate, and can be selected wit the aid of a DIP switch block, which connects one of IC2's outputs Q3-Q8 to the UART clock inputs.

Another DIP switch block, S₂, allows the format of the serial words to be set. The parameters are the number of databits, the number of stop bits, par-

MAIN SPECIFICATIONS

- Conversion from parallel to serial, or serial to parallel (not simultaneously).
- Busy and acknowledge signal available for parallel input.
- Serial output programmable for crossed and non-crossed cable (or DTE/DCE selection);
- Selection between RTS and DTR on serial output.
- Available baud rates: 9,600; 4,800; 2,400; 1,200, 600 and 300.
- Serial data format fully configurable: number of data bits, parity bit, odd/even parity; number of stop bits.
- On-board RS232 voltage level converter.

ity bit yes/no, and odd or even parity. The function of each switch in the DIP block is shown in **Table 1**.

The parallel data enter the circuit via Centronics connector K_1 , and are

fed to a bidirectional databus buffer, IC1. Depending on the logic level applied to pin 1, this buffer copies the data at the Centronics input to the COM8017, or the other way around. At

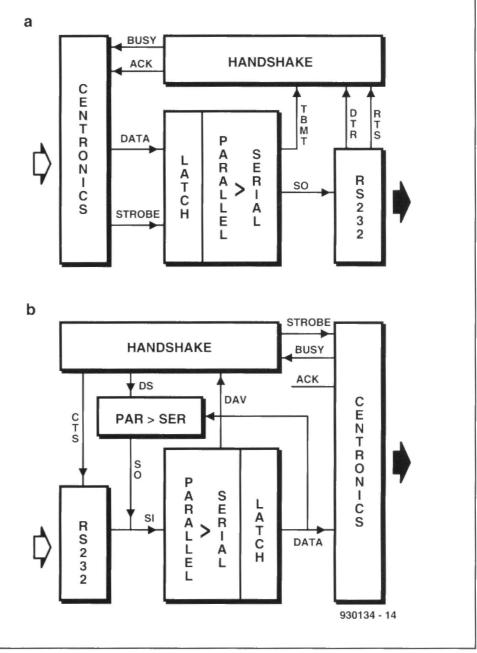


Fig. 1. Two block diagrams for a single circuit with two functions. One (a) for parallel-to-serial conversion, and one (b) for serial-to-parallel conversion.

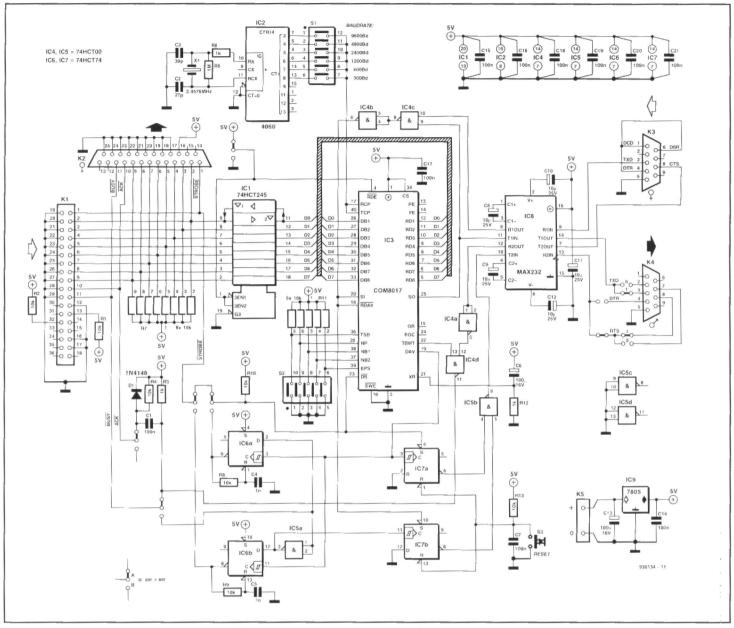


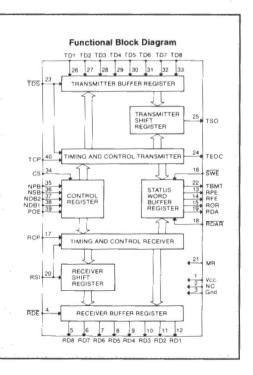
Fig. 2. The heart of the circuit is formed by IC3, a COM8017, which takes care of the data format conversion in both directions (not simultaneously, though).

the other side of the circuit, a special IC is inserted between the serial input and output of the COM8017 to take care of the logic level conversion between the 5-V logic in the converter circuit and the RS232 lines (which carry symmetrical signals with a swing between ± 5 V and ± 15 V). The special IC is a MAX232, which contains a combination of voltage doublers and current-to-voltage converters. Outputs Tlout and T2out supply signals with a swing of about ±10 V. Signals received via the RS232 connectors are applied to the Rlin and R2in inputs (pins 8 and 13) and converted into asymmetrical 5-V levels.

When the parallel-to-serial conversion is done, the serial data is available on pin 25 of IC_3 (SO). After conversion by IC_8 , the data then travel to the TxD or RxD pin of connector K_4 . The selection between these two pins is made with the aid of a jumper, and

UART COM8017

The COM8017 from Standard Microsystems Corp. is a 40-pin integrated circuit with a strong resemblance to the familiar AY-3-1015 (produced by General Instruments Corp., and now obsolete). The COM8017 contains all logic needed to convert parallel data into serial, and vice versa. The block diagram shows the structure of the IC, which contains an input/output buffer and associated shift register, two blocks of logic that serve to arrange the flow of data traffic, a control register and a status register. Although the structure of the IC allows simultaneous two-direction data traffic (full or half-duplex using two virtually separate 'channels'), this feature is not used in the present circuit, since situations requiring simultaneous data format conversion are few and far between.



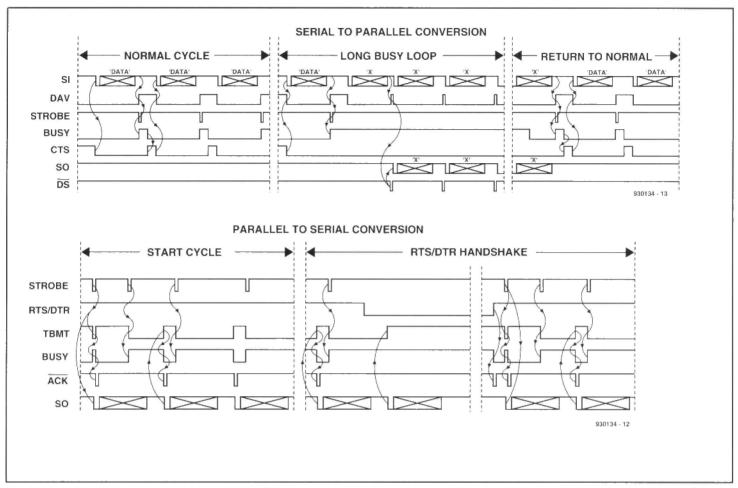


Fig. 3. These timing diagrams should help to elucidate the rather complex operation of the circuit.

depends on the type of serial cable applied, and the type of equipment connected. The position '1' jumpers will typically be fitted near the RS232 connector when the equipment is of the DCE type, while position '2' is used with DTE types, which includes most printers. The options for handshaking with the serial equipment are DTR and RTS. Select one of these in accordance with the requirements of the equipment you wish to connect. The user manual will usually provide this information.

Serial data to be converted into parallel are applied to the converter via connector K3. In this mode, the converter behaves like DCE (data communication equipment), which is based on the assumption that a computer is connected. After the level conversion in ICs, the data travel to the serial input of IC₃ (pin 20). The parallel data available after the conversion is fed out to outputs RD1-RD8. This byte is then conveyed to connector K₂ via buffer IC1. K2 then forms the Centronics output of the converter, and may be used to hook up a printer with a standard Centronics input. The feedback loop indicated in the block diagram is realised by a simple connection between the output buffer (RD1-RD8) and the input buffer (DB1-DB9) of IC_3 .

Handshaking

The circuit diagram shows a number of jumpers that can be fitted in two positions. With the jumpers fitted as shown in the circuit diagram, the converter functions as a parallel-to-serial converter. Signals 'busy' and 'acknowledge' enable the converter to provide its current state information to the equipment connected to K₁. The busy signal is fairly simple to generate. RTS or DTR is active on K4 if the serial equipment is ready to receive data. If the TMBT output of IC3 is also high (transmitter buffer empty), NAND IC₄ pulls the busy line logic low. This level is also used to enable a small network, D_1 - C_1 - R_3 - R_4 , to derive the acknowledge (ACK) pulse, which appears as a logic 0 after the negative-going edge of the busy signal. The 0 indicates that the converter has received and processed data. Next, if new data appears on the Centronics bus, the equipment connected to K_1 will supply a strobe pulse to signal that valid data is available for loading into the converter. This pulse is fed to the DS input of IC₃, which responds by loading the data into its input buffer. Next, the data is converted into serial format, and conveyed to the RS232 receiver. During the conversion, TBMT is low (and, consequently, busy is high),

which means that the converter is not ready to receive new data. Once the serial data converter is no longer capable of handling the incoming datastream, it pulls DTR or RTS low, which also results in a 'high' busy line.

The other way around is 'serial-in, parallel-out'. A jumper is used to reverse the direction of buffer IC_1 (via the logic level applied to pin 1). The acknowledge signal is disconnected from K_1 . The strobe line is turned into an input, and the busy line into an output.

As soon as IC3 detects a negativegoing pulse transition (falling edge) at its serial input (caused by data arriving from K₃), the IC first checks if this is a start pulse by measuring the length of the pulse. The falling edge also pulls the DAV (data available) output of the COM8017 low. This is achieved with the aid of the RDAV\ input. Also, S-R (set-reset) bistable IC_{7b} is set, which is done to inform the serial transmitter, via the CTS line, to stop transmitting after the current byte. After the conversion, the parallel data are available in the output buffer (provided the 'old' data were sent correctly). The presence of this new data is indicated by the DAV output going high. The DAV output clocks bistables IC6a, IC6b and IC7a. Two RC networks, R₈-C₄ and R₉-C₅, turn the two bista-

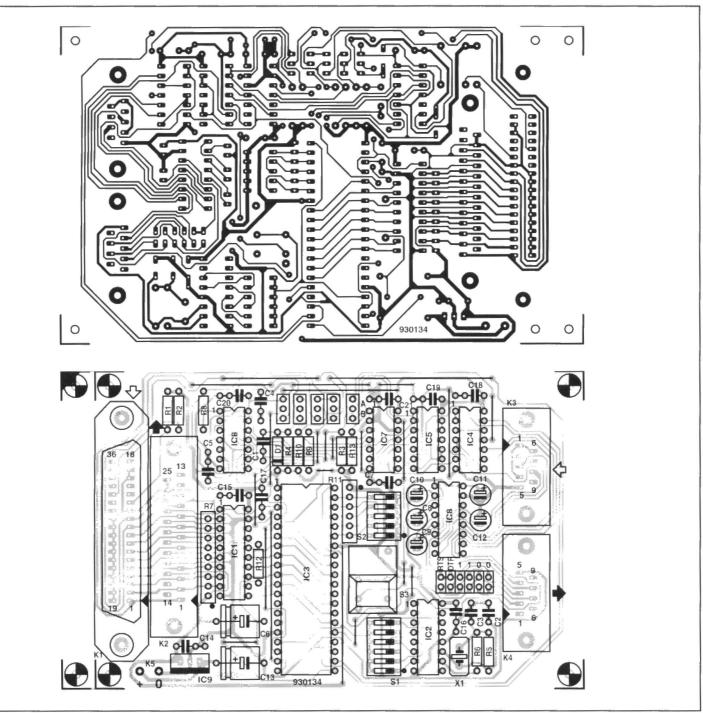


Fig. 4. Track layout and component mounting plan of the printed circuit board designed for the converter.

bles in IC₆ into a monostable. If the equipment connected to K2 is not busy, IC_{6b} will generate a strobe pulse. and the available data is copied to the Centronics equipment connected to the converter. Next, IC7a and IC7b ensure that the RS232 transmitter is informed, via the CTS line, that new data may be transmitted. If the busy line was still high, the D input of IC6b is held at 0, and no strobe pulse is generated. IC6a applies a pulse to the DS input of IC3. This causes the received byte to be sent from the serial output to the serial input via IC_{4b} and IC_{4c} . At the end of this sequence, a DAV signal is generated to ensure that the byte is 'circulated' again if the receiver is still busy. Else, a strobe pulse is generated

for the receiver.

Finally, the circuit has a reset key, S_3 , which is useful when the communication stalls owing to a transmission fault. Pressing this key results in IC_{7a} and IC_{7b} being reset.

The circuit is best powered by an external mains adaptor with an output voltage of 8-15 V d.c. Regulator IC_9 provides the 5-V supply voltage for the circuit. The current consumption of the converter is about 100 mA.

Construction

The printed circuit board for the converter (**Fig. 4**) is designed such that all components are accommodated on a single board. The parallel input and

output connectors are located at one side of the board, while the serial connectors are arranged side-by-side on the other side. All connectors are types with straight solder pins to enable the cables to be connected from the top side of the board. Fitting the parts on to the board should not present problems. IC sockets may be used if you are less confident of your soldering skills. The reset press-key is also fitted directly on to the board. The completed board fits exactly into the enclosure mentioned in the parts list, although clearances have to be cut for the four connectors, the two DIP switches, the press-key and the mains adaptor socket. If you use the enclosure mentioned in the parts list, the voltage reg-

COMPONENTS LIST

Resistors

R1;R2;R4;R8;R9;R10;R13 = $10k\Omega$ R3;R6;R12 = $1k\Omega$

 $R5 = 1M\Omega$

R7 = 8-way $10k\Omega$ SIL array

R11 = 5-way $10k\Omega$ SIL array

Capacitors:

C1:C7:C14-C21 = 100nF

C2 = 27pF

C3 = 39pF

C4:C5 = 1nF

04,00 - 1111

 $C6;C13 = 100\mu F 16V$

 $C8-C12 = 10 \mu F 25 V radial$

Semiconductors:

D1 = 1N4148

IC1 = 74HCT245

IC2 = 4060

IC3 = COM8017

IC4;IC5 = 74HCT00

IC6;IC7 = 74HCT74

IC8 = MAX232

1C9 = 7805

Miscellaneous:

K1 = 36-way Centronics socket; PCB mount; straight pins

K2 = 25-way sub-D socket; PCB mount; straight pins

K3 = 9-way sub-D socket; PCB mount; straight pins

K4 = 9-way sub-D plug; PCB mount; straight pins

K5 = two solder pins

S1 = 6-way DIP switch

S2 = 5-way DIP switch

S3 = Digitast press-key, 12 mm wide cap (ITT/Cannon Switches)

X1 = 2.4576 MHz quartz crystal

1 pinheader 2x6 pins

5 SIL pinheaders, 3 pins

1 Pactec HPkit enclosure; approx.

92x146x28mm

1 printed circuit board 930134 (see page 70)

ulator has to be fitted at the solder side of the board — else, it protrudes too far above the board (see **Fig. 5**).

The circuit can not be taken into use before you have fitted the jumpers in the appropriate positions. The five 3-pin PCB headers at the centre of the PCB must all be set to position 'A' or 'B' (A = parallel-to-serial; B = serial-to-parallel). Further, there are six pin combinations next to K_4 that are used to select the lines used for the serial output. Fit two jumpers in the '1' positions if the connection is a 'real' DTE-to-DCE link (i.e., the device connected to the serial output of the converter is a DCE), and a non-crossed connection cable is used. The jumpers are fitted in

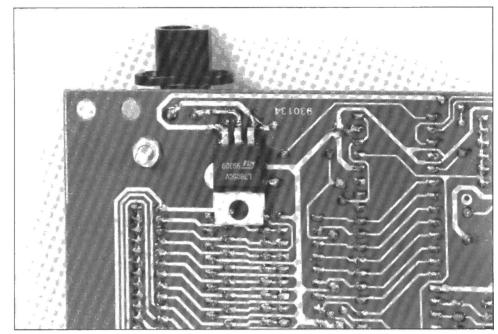


Fig. 5. Unconventionally, voltage regulator IC9 is fitted at the solder side of the board if the plastic enclosure mentioned in the parts list is used.

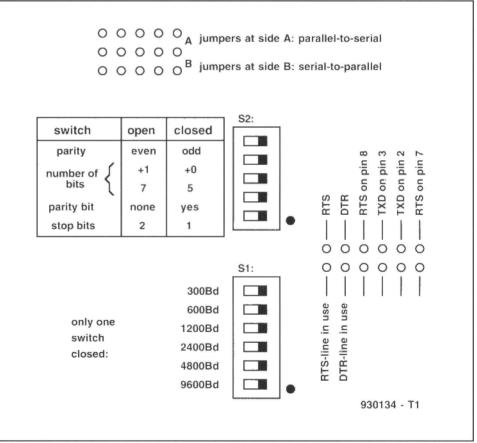


Table 1. Settings of jumpers and DIP switches on the board.

positions '0' if the connection is of the DTE-to-DTE type with a non-crossed cable, or a DTE-to-DCE type with a crossed cable, or a so-called zero-modem. The enclosure may be closed after fitting the jumpers. The baudrate and the serial data format may be set with the aid of the DIP switches.

Should the serial peripheral equipment have a 25-way D-connector, this may be fitted with a 9-to-25-pin adaptor.

74HCT245 74HCT251 74HCT253 74HCT257 74HCT258 74HCT258 74HCT273 74HCT280 74HCT280 74HCT299 74HCT356 74HCT366 74HCT366 74HCT366 74HCT367

74F40

74F51

74F64 74F74 74F86 74F86 74F109 74F112 74F113 74F114 74F126 74F132 74F138 74F138 74F148 74F157 74F153 74F153 74F158

TEL 081-471 9338 TLX 929709 VICOM G FAX 081-552

DI	Gľ	TAL	INT			ED CIF			ECI	ALIST	
4000 SE	RIES	4513B	1.20	4016BT	0.43	74160	0.94	74LS169 74LS170	0.59	74LS669 74LS670	1,07
4000B	0.16	4514B 4515B	1.12	4017BT 4018BT	0.78	74161 A 74163	1.28	74LS173	POA 0.39	74LS673	POA
4000UB 4001A	0.18	45168	0 44	4020BT	0.95	74*64	1.20	74LS173A 74LS:74	0.44	74LS674 74LS682	17 60 2.62
400°B	0.18	4517B	1.B4 0.40	402°BT 4023BT	0.65	74165 74166	1.06	74LS175	0.36	74LS683	POA
1001UB 1002B	0.22	4519B	0.36	4024BT	0.76	74174	1.53	74LS181	1.82	74LS684	3.85
10068	0.39	4520B 4521B	0.36	4025BT 4027BT	0 38	74175 74:80	1 23	74LS182 74LS183	2.05	74LS685 74LS686	POA POA
	0.20	4522B	0.86	4028BT	0.56	74184	POA	74LS189	2.60	74LS687	POA
008B 009AE	0.40	4526B	0.50	4029BT	0.86	74185	1.76	74LS190	0.49	74LS688	98
009JB	0.29	4527B 4528B	0.56	4040BT 4042BT	0.78	74191 74192	1 41	74LS191 74LS192	0.49	74LS693 74LS794	POA POA
0108	0.29	4529B	0.57	4046BT	4"	74193	1.65	74LS193	0.48	74LS795	POA
011UB	0.18	4530B	1.92	4047BT	1.06	74221	1.23	74LS194 74LS194A	0.54	74LS796	POA
012AE	0.16	4531B 4532B	1.14	40498T 4050BT	0.48	74259 74265	2 92	74LS194A 74LS195A	0.57	74LS797 74LS848	POA POA
0128	0.20	4534B	2.82	4051BT	0.78	74273	PDA	74LS196	0.68	74HC SE	THE OWNER OF THE OWNER, WHEN
013B 014B	0.20	4536B	1.22	4052BT	0.84	74276	3.56	74LS197	0.68	74HC00	0.19
015B	0.42	4538B 4539B	0.60	4053BT 4060BT	0.98	74279 74283	1 38	74LS221 74LS224	0.44	74HC02	0.19
016B	0.24	45418	0.52	4066BT	0.59	74298	POA	74LS240	0 42	74HC03 74HC04	0.24
017B 018B	0.3B	4543B 4544B	9.57 2.11	4068BT 4069UBT	0.38	74365 74367	D.70 1.06	74LS241 74LS242	0.42	74HCU4	0.19
019B	0.26	4547B	1.68	40090BT	0.38	74393	2.94	74LS242	0.42	74HC05	0.20
020AE 020B	0 36	4549B	POA	4071BT	0.38	74403	POA	74LS244	0.42	74HC08 74HC10	0.20
0218	0.40	4551B 4553B	1 62	4075BT 4077BT	0.38 0.38	74423	POA	74LS245 74LS247	0.42	74HC11	0.20
022B	0.40	4554B	6.0"	4078BT	0.38	74LS SE	RIES	74LS248	0.68	74HC*4	0.25
023B 023UB	0.20	4555B	0.48	4081BT	0.38	741.000	0.40	74LS249 74LS251	0.99	74HC14A 74HC20	0.22
024AE	0.27	4556B 4557B	0.49	4093BT 4094BT	0.45	74LS00 74LS01	0.18	74LS251	0.32	74HC21	0.22
0248	0 32	4558B	2-8	4508BT	2.05	74LS02	0.4B	74LS256	0.78	74HC27	0.22
025B 026B	0.19	4560B 4561B	1.74	4510BT 4511BT	1.02	74LS03 74LS04	0.18	74LS257 74LS257A	0.34	74HC30 74HC32	0.22
027B	0.30	4562B	5 15	4512BT	0.68	74LS05	0.21	74LS257A	0.44	74HC42	0.48
028B 029B	0.38	4566B	1.10	4514BT	2.20	74LS06	0.51	74LS258A	0.48	74HC51 74HC58	0.29
030B	0.35	4568B 4569B	5.17	4516BT 4518BT	1.02	74LS07 74LSUB	0.51	74LS259 74LS260	0.48	74HC58	0.34
03°B	1.04	4572UB		4520BT	1.18	74LS08	0.18	74LS260 74LS266	0.32	74HC74	0.25
032B 033B	0.70	4573P	POA	4521BT	1 07	74LS10	C 18	74LS273	0.42	74HC75 74HC76	0.40
034B	1.10	4580E 4581B	8 84 3.85	4522BT 4528BT	1.22 0.88	74LS11 74LS12	0.18	74LS275 74LS279	D.33	74HC77	0.51
035B	0.39	4582B	3.85	4534BD	PDA	74LS13	0.19	74LS280	0.86	74HC85	0.48
036B 037B	2.57	4583B	0.86	4538BT	1.05	74LS14	0.24	74LS283	0.45	74HC86 74HC93	0.28
1038B	0.78	4584B 4585B	0.57	4541BT 4543BT	1.05	74LS15 74LS20	0.38	74LS290 74LS292	0.48	74HC107	0.39
039B	3.22	4597CP		4555BT	POA	74LS21	0.*8	74LS293	0.38	74HC109	0.35
U40H D41B	0.42	45988	6 90	4556BT	05	74LS22	0.18	74LS294	7.82	74HC113	0.40
	0.32	4599H 4720B	5.50 POA	4585BT 40106BT	0.95	74LS24 74LS26	0.58	74LS295 74LS295A	1.15	74HC123	0.40
042B	0.32	4720V	POA	40244BT		74LS27	0.10	74LS298	0.98	74HC125	0.40
043B 044B	0.36	47238	POA	40373BT	2.34	74LS28	n 24	74LS299	1 53	74HC126 74HC131	0.47
0458	0.94	4724El 473° VP	1.90	74 SEF	aice.	74LS30 74LS31	0.18 1.58	74LS321 74LS322	3.B2 POA	74HC132	0.32
046B	0.42	4737VP		A SE	IIE-	74LS32	0.20	74LS322A	POA	74HC133	9.32
1047B 1048B	0.38	4738VP		7400	0.36	74LS33	0.20	74LS323	3.24	74HC137 74HC138	0.76
049B	0.02	4750VD 4752VP	28 50	7401	0.30	74LS37 74LS38	0.18 0.18	74LS347 74L5348	2.86 1.98	74HC139	0.31
	0.28	4753VP		7403	0.34	74LS40	0.1B	74LS352	: 68	74HC141	0.61
1050B 105°B	0.22	4754VP		7404	0.40	74LS42	0.32	74LS353	1.68	74HC147 74HC148	0.61
052B	0.33	40085 40097	1.98 0.62	7405 7406	0.68	74LS44 74LS47	2.11	74LS363 74LS364	2.10 POA	74HC151	0.40
1053B	0.34	40098	n 62	7406A	0.72	74LS48	0.54	74LS365	0.30	74HC153	0.40
10542 10558	0.68	40100	2.48	7407	0.63	74LS49	1.3B	74LS365A	0.34	74HC155	0.98
1056B	0.48	40101	POA 1.20	7407A 7408	0.65	74LS51 74LS54	0.19	74LS366 74LS366A	0.35	74HC157	0.42
1059B	2 98	40103	a 88	7409	0.67	74LS55	0.32	74LS367	0.29	74HC158	0.47
1060B 1063B	0.42	40105	1 92	7410	0.35	74LS73	0.48	74LS367A 74LS36R	0.36	74HC160 74HC161	0.64
IN668	0.27	40107	0.42	7413	0.76	74LS73A 74LS74	0.22	74LS368A	1.72	74HC162	0.64
1967B 1968B	0.20	40108	POA	7414	0.72	74LS74A	0.24	741 5373	0.38	74HC163 74HC164	0.42
1069UB	0.21	40109 40*10	1 24	74°6 7417	0.53	74LS75 74LS76	0.28	74LS374 74LS375	0.44	74HC165	0.55
1070B	0.21	40! 14	2.62	7420	0.46	74LS76A	0.72	74LS377	0.66	74HC166	0.88
n71∂ 072B	0.20	40116	12.48	7425	0.59	74LS77	0.42	74LS378	0 98	74HC173 74HC174	0.76
072B	0.20	40117	1.80	7426	0.48	74LS78	0.32	74LS379 74LS381A	0.99	74HC174	0.36
075B	0.19	40147	1 23	7427	0.59	74LS83 74LS83A	0.39	74LS385	4.96 3.48	74HC181	94
1076B 1077B	0.42	40161	0.54	7432	0.45	74LS85	0.38	74LS386	0.98	74HC182 74HC190	0.59
0788	0.21	40162 40163	0.54	7437 7438	0.59	74LS86 74LS90	0.27	74LS390 74LS393	0.46	74HG191	0.52
DB1H	0.18	40'74	0.34	7440	0 77	74LS91	POA	74LS395	0.66	74HC192	0.77
1082B 1085B	0.20	40175	0.47	7442	0.55	74LS92	POA	74LS395A	0.94	74HC193 74HC194	0.67
086B	0.38	4018° 40192	POA 0.62	7445	1.53	74LS93 74LS95	0.44 0.48	74LS396 74LS398	POA	74HC195	0.47
0898	0.98	40*93	0.74	7447	0.98	74L596	0.82	74LS399	0.81	74HC221	0.44
ID93B IO94B	0.24	40194	1.82	7447A	1 67	74LS107	0.28	74LS423	0.98	74HC237 74HC238	0.73
1095B	0.70	40195	2.24	7451 7454	0.57	74LS107A 74LS109	0.3B 0.2B	74LS445 74LS450	POA 10.68	74HC240	0.44
I096B	1 10	40244	1.36	7470	0.54	74L5109A	0.32	74LS46" A	7.16	74HC241	0 44
0978 098B	2.75	40245	0.54	7472	0.38	74LS112 74LS112A	0.28	74LS465	3.82	74HC242 74HC243	0.80 0.88
099B	0.42	40257	1.10	7474	0.59	74LS112A 74LS113	0.39	74LS467 74LS468	7.78 7.78	74HC244	0.43
104P 160B	1.01 U.B5	40374	1.10	7475	0.67	74L5113A	0.38	74LS469	6.10	74HC245	0.44
1618	0.85	45026	4.42 5.99	7476 7480	0.72	74LS114 74LS114A	0.32	74LS469A 74LS490	6.70 2.85	74HC251 74HC253	0.52
174B	27	45028	4.49	7483	1 10	74L5114A	0.39	74LS491A		74HC257	0.47
1758	1.14	45040	POA	7485	0.58	74LS123	0.36	74LS502	POA	74HC258	0.73
194B 409P	1.43	45041	POA	7486 7490	0.53	74LS125 74LS125A	0.28	74LS540	08.0	74HC259 74HC266	0.65
410P	16.45	45106 45106	7.98	7490A	1.34	74LS*26	0.32	74LS541 74LS569	0 80 POA	74HC273	0.54
411P : 412FP		45109	POA	7491	2.56	74LS126A	0.36	74LS573	.34	74HC279 74HC280	0.51
	POA	45138	POA	7492	0.67	74LS132	0.29	74LS574	1.34	74HC280 74HC283	0.58
412VP		45145 45146	10 04 POA	7497A 7493	0.68	74LS133 74LS136	0.78	74LS590 74LS592	4.85 5.28	74HC298	0.73
416P	PDA	4515	19.50	7493A	0.70	74LS137	0.98	74LS593	5.79	74HC299	1.09
419P 429PB	POA	45152	21 45	7495A	1 10	74LS138	0.31	74LS595	4.85	74HC323 74HC354	1 58
433P	POA	45156 45157	15 80 14.38	7497 74104	5.23 D.67	74LS139 74LS145	0.66	74LS597 74LS621	POA	74HC356	0.65
443P	POA	45158	: 1.94	74107	0.60	74LS147	2.86	74LS622	POA	74HC365	0.41
447P 468P	POA	45159	POA	74110	POA	74LS148	0.83	74LS623	2.98	74HC366 74HC367	0.52
469P	POA	45406 45407	2.73 6.47	74116 74118	3 10 POA	74LS151 74LS153	0.32	74LS624 74LS625	5.37	74HC368	0.52
	POA	45411	POA	74119	POA	74LS153 74LS154	1 12	74LS626	POA	/4HC373	0.44
	3.20 6.27	454~4	15.60	74121	0.98	74LS155	0.34	741 S627	POA	74HC374	0.44
490P	13.58	45428	POA	74123	0.94		0.38	74LS628	1.78	74HC375 74HC377	0.76
490P 495P	6.24	45443 45440	POA	74125 74126	0.67 0.98	74LS157 74LS158	0.34	74LS629 74LS631	1.98 POA	74HC386	0.29
490P 495P 497P 499P		45441	POA	74128	1.19	74LS160	0.48	74LS639	POA	74HC390	0.38
490P 495P 497P 499P 500B	19.45			74132	0.86	74LS~60A	0.54	74LS640	0.98	74HC393 74HC423	0.41
490P 495P 497P 499P 500B 501B	D.32	ADDO-ST			1 16	74LS16*	0.46	74LS641	0.98	74110423	
490P 495P 497P 499P 500B 501B 502B	n.32 0.38	4000 SI SURF	ACE	74145	9 4300			TALOP		74HC521	0.95
490P 495P 497P 499P 500B 501B 502B 503B 504B	0.38 0.38 0.38 1 12	SURF	ACE INT	74150	1.86 0.80	74LS161A		74LS641-1 74LS642	1.28 0.98	74HC521 74HC533	0.95
490P 495P 497P 499P 500B 501B 502B 503B 504B 504B	0.38 0.38 0.38 1 12 4.42	SURF MOU 4001B1	ACE INT 0.32	74150 7415* 74151A	1.86 0.80 0.80	74LS161A 74LS162 74LS162A	0.48	74LS641-1 74LS642 74LS642-1	0.9B POA	74HC533 74HC534	0.95 0.89
490P 495P 497P 499P 500B 501B 502B 503B 504B 506B 506B	0.38 0.38 1.12 4.42 1.14	9URF MOU 4001BT 4002BT	ACE INT 0.32 0.32	74151 74151 74151 74153	08.0 08.0 09.0	74LS161A 74LS162 74LS162A 74LS163	0.48 1.07 0.42	74LS642 74LS642-1 74LS643	D.9B POA POA	74HC533 74HC534 74HC540	0.95 0.89 0.69
490P 495P 497P 500B 501B 502B 503B 504B 505B 506B 506B 506B	D.32 0.38 0.38 1.12 4.42 1.14 1.14	4001BT 4002BT 4002BT 4011BT 4011UE	ACE INT 0.32 0.32 0.32 0.32 8T0.32	74150 74151 74151A 74153 74154	0.80 0.80 0.90 2.16	74LS161A 74LS162 74LS162A 74LS163 74LS163A	0.48 1.07 0.42 0.47	74LS642 74LS642-1 74LS643 74LS644	POA POA POA	74HC533 74HC534 74HC540 74HC541 74HC563	0.95 0.89 0.69 0.60 0.88
490P 495P 497P 499P 500B	0.38 0.38 1.12 4.42 1.14	SURF MOU 4001BT 4002BT 4011BT	0.32 0.32 0.32 0.32 0.32 0.32	74151 74151 74151 74153	08.0 08.0 09.0	74LS161A 74LS162 74LS162A 74LS163	0.48 1.07 0.42	74LS642 74LS642-1 74LS643	POA POA POA POA 1.12	74HC533 74HC534 74HC540 74HC541	0.95 0.89 0.69 0.60

M		74HC589
		74HC590
w		74HC592
•		74HC593
-		74HC595 74HC597
		74HC620
094	6	74HC620 74HC623 74HC633
07	- 1	74HC640 74HC643
IS1		74HC643
		74HC645
669	1,07	74HC646 74HC648
670 673	0.78 POA	74HC652 74HC658 74HC658
674	17 60	74HC652
682	2.62	74HC659
683 684	POA 3.85	74HC664
685	POA	74HC659 74HC664 74HC665 74HC670
686	POA	74HC677
687 688	POA 98	74HC677 74HC678
693	POA	74HC680 74HC682 74HC684
794 795	POA	74HC684
795 706	POA POA	74HC688
796 797	POA	74HC698 74HC690 74HC691
848	POA POA POA POA RIES 0.19 0.24 0.19 0.24 0.20 0.20	74HC692
C SE	RIES	74HC692 74HC693 74HC696 74HC697
00	0.19	74HC696
02	0.19	74HD698
04	0.19	74HC699 74HC4002
1104	0.24	74HC4002
08	0.20	74HC4015 74HC4016 74HC4017
10	0.29	74HC4017
10 11 14 14A 20	0.20	74HC4020 74HC4020 74HC4024 74HC4024 74HC4040
14A	0.25	74HC4024
20	0.22	74HC4028
21	0.22 0.22	74HG4046
21 27 30 32	0.22	74HC4046 74HC4649
32	0.22	74HC4050
42 51 58	0.48	74HC4050 74HC4050 74HC4052
58	0 42	74HC4053 74HC4053
73 74	0.42 0.34 0.25	74HC4060
75	0.25	74HC4060 74HC4061 74HC4066
75 76 77	0.40	74HC4066
77 85	0.51 0.48	74HC4066
86	0.28	74HC4073
.93	0.44	74HC4076 74HC4076 74HC4094
107	0.39	74HC4094
12	0 40	
113	0.40	74HC4351
123	0.40	74HC4514
126	0.47	74HC4316 74HC4511 74HC4514 74HC4515 74HC4518 74HC4520
-31	0.52 0.32	74HC4516
133	0.32	74HC4534 74HC4538
137	0.32 0.76	74HC4538
138	0.34	74HC4547 74HC700
141	0.61	74HC7002
147	0.61	74HC7032 74HC7266
148	0.55	74HC7074 74HC7292 74HC7294
153	0 40 0 40	74HC7292
54	0.98	74HC/28M
133	0.69	74HC4010 74HC4010 74HC4010
157		
1109 1112 1112 1112 1112 1112 1112 1132 113	0.47	
160	0.47 0.64 0.42	74HCT SE
160	0.64 0.42 0.64	
160	0.64 0.42 0.64 0.42	74HCT00 74HCT02
160	0.64 0.42 0.64 0.42	74HCT00 74HCT02 74HCT03
160	0.64 0.42 0.64 0.42 0.42 0.55 0.88	74HCT00 74HCT02 74HCT03 74HCT04
160	0.64 0.42 0.64 0.42 0.42 0.55 0.88 0.76	74HCT00 74HCT02 74HCT03 74HCT04
160	0.64 0.42 0.64 0.42 0.42 0.55 0.88 0.76 0.42	74HCT00 74HCT02 74HCT03 74HCT04
160	0.64 0.42 0.64 0.42 0.42 0.55 0.88 0.76 0.42 0.36	74HCT00 74HCT02 74HCT03 74HCT04 74HCT08 74HCT10 74HCT11 74HCT11
160 161 162 163 164 165 166 173 174 175 181	0.64 0.42 0.64 0.42 0.42 0.55 0.88 0.76 0.42 0.36 1.94 0.59	74HCT00 74HCT02 74HCT03 74HCT04 74HCT08 74HCT10 74HCT11 74HCT11
160 161 162 163 164 165 166 173 174 175 181	0.64 0.42 0.64 0.42 0.55 0.88 0.76 0.42 0.36 1.94 0.59 0.67	74HCT00 74HCT02 74HCT03 74HCT04 74HCT08 74HCT10 74HCT11 74HCT11
160 161 162 163 164 165 166 173 174 175 181	0.64 0.42 0.64 0.42 0.55 0.88 0.76 0.42 0.36 1.94 0.59 0.67 0.52 0.77	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT11 74HCT11 74HCT14 74HCT20 74HCT27 74HCT27
160 161 162 163 164 165 166 173 174 175 181	0.64 0.42 0.64 0.42 0.55 0.88 0.76 0.42 0.36 1.94 0.59 0.67 0.52 0.75 0.52	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT11 74HCT11 74HCT14 74HCT20 74HCT27 74HCT27
160 161 162 163 164 165 166 173 174 175 181	0 64 0 42 0.64 0.42 0.42 0.58 0.76 0.42 0.36 1.94 0.59 0.67 0.52 0.77 0.52	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT11 74HCT11 74HCT14 74HCT20 74HCT27 74HCT27
0160 0161 0162 0163 0164 0165 0174 0175 0181 0182 0190 0191 0192 0193 0194 0194 0194	0.64 0.42 0.64 0.42 0.55 0.88 0.76 0.42 0.36 1.94 0.57 0.52 0.77 0.54 0.67 0.47	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT11 74HCT14 74HCT12 74HCT27 74HCT27 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT42
0160 0161 0162 0163 0164 0165 0174 0175 0181 0182 0190 0191 0192 0193 0194 0194	0.64 0.42 0.64 0.42 0.55 0.88 0.76 0.42 0.36 1.94 0.57 0.52 0.77 0.54 0.67 0.47	74HCT00 74HCT02 74HCT03 74HCT03 74HCT04 74HCT11 74HCT11 74HCT21 74HCT21 74HCT27 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT34 74HCT37 74HCT37 74HCT37
1160 1161 1162 1163 1164 1165 1173 1174 1175 1181 1182 1190 1191 1192 1193 1194 1195 1192 1193 1194 1195 1195 1195 1195 1195 1195 1195	0.64 0.42 0.64 0.42 0.55 0.88 0.76 0.36 0.94 0.59 0.67 0.52 0.77 0.54 0.67 0.44 0.73 0.64	74HCT00 74HCT02 74HCT03 74HCT03 74HCT04 74HCT11 74HCT11 74HCT21 74HCT21 74HCT27 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT34 74HCT37 74HCT37 74HCT37
1160 1161 1163 1164 1165 1166 1173 1174 1175 1181 1182 1190 1191 1194 1195 1221 1237 1238 1240 1241	0.64 0.42 0.42 0.42 0.55 0.86 0.76 0.42 0.59 0.67 0.52 0.77 0.54 0.67 0.47 0.47 0.47	74HCT00 74HCT02 74HCT03 74HCT03 74HCT04 74HCT11 74HCT11 74HCT21 74HCT21 74HCT27 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT34 74HCT37 74HCT37 74HCT37
1160 1161 1163 1164 1165 1166 1173 1174 1175 1181 1182 1190 1191 1194 1195 1221 1237 1238 1240 1241	0.64 0.42 0.42 0.42 0.55 0.86 0.46 0.36 0.47 0.57 0.67 0.67 0.44 0.67 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT14 74HCT27 74HCT32 74HCT32 74HCT32 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36
7160 7161 7162 7163 7164 7165 7174 7175 7174 7175 7174 7175 7181	0.64 0.42 0.42 0.42 0.55 0.86 0.46 0.36 0.47 0.57 0.67 0.67 0.44 0.67 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT14 74HCT27 74HCT32 74HCT32 74HCT32 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36
7160 7161 7162 7163 7164 7165 7174 7175 7174 7175 7174 7175 7181	0 644 0 42 0 42 0 45 0 688 0 76 0 69 0 67 0 67 0 67 0 67 0 67 0 67 0 67 0 67	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT14 74HCT27 74HCT32 74HCT32 74HCT32 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT35 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36 74HCT36
7160 7161 7162 7163 7164 7165 7174 7175 7174 7175 7174 7175 7181	0 644 0 422 0 452 0 688 0 766 0 867 0 677 0 677 0 677 0 677 0 444 0 680 0 688 0 644 0 680 0 644 0 680 0 688 0 644 0 680 0 688 0 644 0 688 0 688	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT20 74HCT27 74HCT32 74HCT32 74HCT32 74HCT32 74HCT42 74HCT42 74HCT46 74HCT66 74HCT66 74HCT67 74HCT11 74HCT10 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112 74HCT112
7160 7161 7162 7163 7164 7165 7174 7175 7174 7175 7174 7175 7181	0 642 0 42 0 42 0 42 0 45 0 88 0 76 0 142 0 36 0 77 0 52 0 67 7 0 52 0 44 0 44 0 44 0 44 0 44 0 44 0 44 0 4	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT11 74HCT12 74HCT27 74HCT27 74HCT27 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT112
7160 7161 7162 7163 7164 7165 7174 7175 7175 7179 7179 7199 7199 7199 7199	0 642 0 42 0 42 0 45 0 48 0 76 0 88 0 76 0 67 0 67 0 67 0 67 0 67 0 68 0 69 0 67 0 64 0 64 0 64 0 64 0 64 0 64 0 64 0 64	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT11 74HCT12 74HCT27 74HCT27 74HCT27 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT112
7160 7161 7162 7163 7164 7165 7174 7175 7175 7179 7179 7199 7199 7199 7199	0 642 0 42 0 42 0 42 0 45 0 68 0 48 0 69 0 69 0 67 0 67 0 67 0 44 0 43 0 43 0 43 0 43 0 43 0 43 0 63 0 63 0 64 0 64 0 64 0 64 0 64 0 64 0 64 0 64	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT13 74HCT14 74HCT14 74HCT14 74HCT14 74HCT14 74HCT14 74HCT14 74HCT14 74HCT14 74HCT14 74HCT14 74HCT1
7160 7161 7162 7163 7164 7165 7174 7175 7175 7179 7179 7199 7199 7199 7199	0 642 0 422 0 422 0 422 0 422 0 422 0 427 0 888 0 76 0 52 0 777 0 47 0 44 0 80 0 44 0 80 0 44 0 80 0 80 0 80	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT04 74HCT04 74HCT14 74HCT26 74HCT27 74HCT37 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT33 74HCT33 74HCT33 74HCT33 74HCT11 74HCT1
7160 (7161 (0 64 0 42 0 .64 0 .64 0 .64 0 .65 0 .67 0 .69 0 .67 0 .67 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0 .64 0 .67 0	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT12 74HCT12 74HCT13 74HCT12 74HCT13 74HCT1
7160 (7161 (0 64 0 42 0 .64 0 .64 0 .64 0 .65 0 .64 0 .67 0 .65 0 .66 0 .67 0 .64 0 .67 0 .64 0 .64 0 .64 0 .64 0 .64 0 .64 0 .64 0 .64 0 .65 0 .64 0 .65 0	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT12 74HCT12 74HCT13 74HCT12 74HCT13 74HCT1
7160 (7161 (0 64 0 42 0 .64 0 .64 0 .64 0 .65 0 .64 0 .67 0 .65 0 .66 0 .67 0 .64 0 .67 0 .64 0 .64 0 .64 0 .64 0 .64 0 .64 0 .64 0 .64 0 .65 0 .64 0 .65 0	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT12 74HCT12 74HCT13 74HCT12 74HCT13 74HCT1
7160 (7161 (0 64 0 42 0 .64 0 .64 0 .64 0 .65 0 .67 0 .67 0 .67 0 .67 0 .67 0 .64 0 .68 0 .64 0 .68 0	74HCT00 74HCT00 74HCT02 74HCT03 74HCT04 74HCT10 74HCT11 74HCT11 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT11 74HCT1
7160 (7161) (7161) (7161) (7161) (7161) (7162) (7163) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (717	0 64 0 42 0 66 0 67 0 67 0 67 0 67 0 67 0 67 0 6	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT04 74HCT14 74HCT14 74HCT14 74HCT14 74HCT12 74HCT14 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT32 74HCT15 74HCT16 74HCT1
7160 (7161) (7161) (7161) (7161) (7161) (7162) (7163) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (717	0 64 2 0.42 0.64 0.64 0.42 0.55 0.65 0.76 0.76 0.76 0.76 0.76 0.76 0.76 0.76	74HCT00 74HCT00 74HCT08 74HCT08 74HCT08 74HCT10 74HCT11 74HCT11 74HCT12 74HCT12 74HCT12 74HCT32 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT13 74HCT1
7160 (7161) (7161) (7161) (7161) (7161) (7162) (7163) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (7174) (7175) (717	0 64 0 42 0 64 0 64 0 64 0 65 0 67 0 67 0 67 0 67 0 67 0 67 0 67	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT10 74HCT11 74HCT14 74HCT12 74HCT12 74HCT13 74HCT12 74HCT13 74HCT1
7160 (7161) (7161) (7161) (7161) (7161) (7161) (7162) (7163) (716	0 64 2 0.42 0.42 0.64 0.64 0.55 0.65 0.56 0.56 0.56 0.56 0.56 0.56	74HCT00 74HCT02 74HCT02 74HCT03 74HCT04 74HCT04 74HCT14 74HCT14 74HCT14 74HCT12 74HCT14 74HCT32 74HCT12 74HCT13 74HCT112 74HCT13 74HCT112 74HCT13
7160 (7161) (716	0 64 2 0.49 0.49 0.49 0.49 0.49 0.49 0.49 0.49 0.40 0.	74HCT00 74HCT02 74HCT03 74HCT03 74HCT04 74HCT10 74HCT11 74HCT14 74HCT12 74HCT12 74HCT13 74HCT12 74HCT13 74HCT1
7160 (7161) (716	0 642 0.492	74HCT00 74HCT02 74HCT03 74HCT03 74HCT04 74HCT04 74HCT14 74HCT14 74HCT14 74HCT12 74HCT13 74HCT12 74HCT13 74HCT1
7160 7161 7161 7161 7161 7161 7161 7162 7163 71	0 64 0 42 0 44 0 45 0 65 1 65 0 65 1	74HCT00 74HCT02 74HCT03 74HCT03 74HCT04 74HCT04 74HCT14 74HCT14 74HCT14 74HCT12 74HCT13 74HCT12 74HCT13 74HCT1
1160 1161 1161 1161 1161 1161 1161 1163 1164 1165 1166 1173 1175 11	0 64 0 42 0 68 0 68 0 68 0 68 0 68 0 68 0 68 0 6	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT04 74HCT14 74HCT14 74HCT14 74HCT17 74HCT14 74HCT32 74HCT16 74HCT1
1160 1161 1161 1161 1161 1163 1164 1165 1164 1165 1165 1165 1165 1165 1173 1175 11	0 64 0 42 0 69 0 69 0 69 0 69 0 69 0 69 0 69 0 6	74HCT00 74HCT02 74HCT03 74HCT04 74HCT04 74HCT04 74HCT14 74HCT14 74HCT14 74HCT17 74HCT14 74HCT32 74HCT16 74HCT1
1160 1161 1161 1161 1161 1163 1164 1165 1164 1165 1165 1165 1174 1165 1174 1175 11	0 64 0 42 0 44 0 45 0 46 4 0 47 0 48 0 49 0 49 0 49 0 49 0 49 0 49 0 49	74HCT00 74HCT00 74HCT02 74HCT03 74HCT04 74HCT14 74HCT14 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT13
1160 1161 1161 1161 1161 1161 1161 1162 1164 1166 1173 1166 1173 1175 11	0 64 0 42 0 49 0 69 4 0 69 4 0 69 4 0 69 4 0 69 4 0 69 4 0 69 6 0	74HCT00 74HCT02 74HCT02 74HCT03 74HCT04 74HCT04 74HCT04 74HCT07 74HCT17 74HCT117
1160 1161 1161 1161 1161 1161 1161 1162 1164 1166 1166 1167 11	0 64 0 42 0 42 0 42 0 42 0 42 0 42 0 42	74HCT00 74HCT02 74HCT03 74HCT04 74HCT08 74HCT10 74HCT11 74HCT11 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT11 74HCT1
1160 1161 1161 1161 1161 1161 1161 1162 1163 1164 1165 1166 1167 1165 1166 1167 11	0 64 0 42 0 42 0 42 0 42 0 42 0 42 0 42	74HCT00 74HCT02 74HCT03 74HCT04 74HCT08 74HCT10 74HCT11 74HCT11 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT11 74HCT1
1160 1161 1161 1161 1161 1161 1161 1162 1164 1166 1166 1167 11	0 64 0 42 0 44 0 47 0 47 0 48 0 47 0 48 0 47 0 48 0 47 0 47	74HCT00 74HCT00 74HCT02 74HCT03 74HCT04 74HCT10 74HCT14 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT12 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT13 74HCT112 74HCT12

HC659	4.40	74HCT368	0.80	74F126
HC664	4.49 4.49	74HCT373	0.44	74F132
HC665	4,49	74HCT374	0.55	74F138
HC670	1 10 3.78	74HCT377	0.64	74F139
HC677	3.78	74HCT390 74HCT393 74HCT394	0.68	74F148
HC678 HC680	5.91 3.83	74HCT393	0.68	74F15° 74F153
HC682	4.21	74HCT423	0.00	74F153 74F157
HC684	5 70	74HCT533	1.44	
HC688	0.87	74HCT534	1.44 0.75	74F160
HC690	1.62		0.64	74F160A
HC691	1.62	74HCT541	0.64	74F161
HC692	1.73	74HCT563	0.98	74F162
HC693	1 73	74HCT564	0.78	74F163
HC696 HC697	1.48	74HCT573 74HCT574	0.64	74F164 74F166
HC698	1.24	74HCT583	0.00	74F168
HC699	1.24	74HCT597	52	74F169
HC4002 HC4015	0.35	74HCTE40	1.34	74F*74
HC4015	1.07	74HCT643	1.34	74F175
HC4016	0.44	74HCT645	1.11	74F181
HC4017	0.42		2.40	74F182 74F189
HC4020 HC4022	0.52		1.64	
HC4024	0.50	74HCT652	0.00	74F191
HC4028	0.58	74HCT652 74HCT670 74HCT673	1 10	74F192
HC4040	0.50	74HCT673	1.64	74F193
HC4046	1.54	1.74HGT688	1.10	74F194
HC4649	0 48	74HCT4002	0.39	74F195
HC4050 HC4051	0.36	74HCT4015 74HCT4016	1.13	74F219
HC4052	0.68		0 52 0.68	74F224 74F240
HC4053	0.68		0.74	74F241
HC4053A	1 10	74HCT4024	0.68	74F244
HC4060	0.47	74HCT4040	0.70	74F245
HC4061	2.52	74HCT4046	2.10	74F251
HC4066	0.46	74HCT4040 74HCT4046 74HCT4051 74HCT4052	0 96	74F251A
HC4066A		74HGT4052	0.95	74F253
HC4067	4 72 0 45	74HCT4053	2.24	74F257 74F257A
HC4072 HC4075	0.32	74HCT4059 74HCT4060 74HCT4066	0.84	74F25B
HC4078	0.46	74HCT4066	0.66	74F259
HC4094	0.64	74HCT4067	4.93	74F260
HC4316	0.68	74HCT4075	0.36	74F269
HC4351 HC4511	0.89		0.84	74F273 74F280
HC4511	0.55	74HC14316	0.68	74F280
HC4514 HC4515	1.38	74HCT4351 74HCT4510 74HCT4511	1 04	74F283 74F299
HC4518	0.80	74HCT4510	1.54 0.94	74F299 74F323
HC4520	0.72	74HCT4514	1.64	74F350
HC4534	0.00	74HCT4515	2.50	74F352
HC4538	0.68	74HCT4516 74HCT4520	161	74F353
HC4543	0.81	74HCT4520	0.90	74F365
HC700*	1.01	74HCT4538	1.02	74F366
HC7002 HC7032	1 01		0.39	74F367 74F368
HC7032	1.01	74HC17046	2 80	74F368 74F373
HC7074	1.99	74HCT40102	2 43 1.48	74F374
HC7292	1.10	74HCT40104	2.71	74F377
HC7294	1 10	74HCT40105	1.82	74F378
HC7294 HC40102	1 10	24110 0501	_	74F378 74F381
HC40103				74F385
HC40105	1.40	MOUNT		74F395
HOTEE	HEC		0.32	74F399
HCT SEF	RIES	74HC00M	0.32	74F412
		74HC00M 74HC02M	0.32	74F412 74F4*3
HCT00	0.22	74HC00M 74HC02M 74HC03M 74HC04M	0.32 0.32 0.32	74F412
HCT00 HCT02 HCT03	0.22	74HC00M 74HC02M 74HC03M 74HC04M	0.32 0.32 0.32	74F412 74F4*3 74F432 74F521 74F524
HCT00 HCT02 HCT03	0.22 0.22 0.26 0.26	74HC00M 74HC02M 74HC03M 74HC04M 74HC004 74HC008M	0.32 0.32 0.32 0.32 0.32	74F412 74F4*3 74F432 74F521 74F524 74F533
HCT00 HCT02 HCT03 HCT04 HCT08	0.22 0.22 0.26 0.22 0.22	74HC00M 74HC02M 74HC03M 74HC04M 74HC004 74HC008M	0.32 0.32 0.32 0.32 0.32 0.32	74F412 74F4*3 74F432 74F521 74F524 74F533 74F534
HCT00 HCT02 HCT03 HCT04 HCT08	0.22 0.22 0.26 0.22 0.22	74HC00M 74HC02M 74HC03M 74HC04M 74HC004 74HC08M 74HC10M	0.32 0.32 0.32 0.32 0.32 0.36	74F412 74F413 74F432 74F521 74F524 74F533 74F534 74F537
HCT00 HCT02 HCT03 HCT04 HCT08 HCT11	0.22 0.22 0.26 0.22 0.22 0.22	74HC00M 74HC02M 74HC03M 74HC04M 74HC004 74HC00M 74HC10M 74HC10M 74HC20M	0.32 0.32 0.32 0.32 0.32 0.36 0.36	74F412 74F4*3 74F432 74F521 74F524 74F533 74F534 74F537 74F538
HCT00 HCT02 HCT03 HCT04 HCT08 HCT11	0.22 0.22 0.26 0.22 0.22 0.22	74HC00M 74HC02M 74HC03M 74HC04M 74HCU04 74HC00M 74HC10M 74HC14M 74HC20M	0.32 0.32 0.32 0.32 0.32 0.36 0.36	74F412 74F4*3 74F432 74F521 74F524 74F533 74F534 74F537 74F538 74F539
HCT00 HCT02 HCT03 HCT04 HCT08 HCT11	0.22 0.22 0.26 0.22 0.22 0.22	74HC00M 74HC02M 74HC03M 74HC04M 74HCU04 74HC00M 74HC10M 74HC14M 74HC20M	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36	74F412 74F413 74F432 74F521 74F524 74F533 74F534 74F537 74F538 74F539 74F540
HCT00 HCT02 HCT03 HCT04 HCT08 HCT11 HCT11 HCT14 HCT14 HCT20 HCT21	0.22 0.26 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC02M 74HC03M 74HC04M 74HC104 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC32M 74HC32M 74HC32M 74HC32M 74HC32M	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36	74F412 74F413 74F432 74F521 74F524 74F533 74F534 74F537 74F538 74F539 74F540
HCT00 HCT02 HCT03 HCT04 HCT08 HCT11 HCT11 HCT14 HCT20 HCT21 HCT27 HCT30	0.22 0.26 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC02M 74HC03M 74HC04M 74HC104 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC32M 74HC32M 74HC32M 74HC32M 74HC32M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36	74F412 74F4*3 74F432 74F432 74F521 74F534 74F534 74F537 74F538 74F540 74F541 74F541 74F543 74F543
HCT00 HCT02 HCT03 HCT03 HCT04 HCT08 HCT11 HCT14 HCT14 HCT20 HCT21 HCT21 HCT27 HCT30 HCT32	0.22 0.26 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC02M 74HC03M 74HC04M 74HC104 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC32M 74HC32M 74HC32M 74HC32M 74HC32M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36	74F412 74F4*3 74F432 74F432 74F521 74F534 74F534 74F537 74F538 74F540 74F541 74F543 74F544 74F543
HCT00 HCT02 HCT03 HCT03 HCT04 HCT08 HCT11 HCT14 HCT14 HCT20 HCT21 HCT21 HCT27 HCT30 HCT32	0.22 0.26 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC02M 74HC03M 74HC04M 74HC104 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC32M 74HC32M 74HC32M 74HC32M 74HC32M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36	74F412 74F413 74F432 74F521 74F524 74F533 74F534 74F538 74F539 74F540 74F540 74F544 74F544 74F544 74F544
HCT00 HCT02 HCT03 HCT04 HCT04 HCT11 HCT11 HCT14 HCT26 HCT27 HCT30 HCT30 HCT32 HCT32	0.22 0.26 0.22 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC02M 74HC03M 74HC04M 74HC04M 74HC10M 74HC14M 74HC30M 74HC30M 74HC33M 74HC32M 74HC75M 74HC86M 74HC86M 74HC86M 74HC123AM 74HC123AM	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36	74F412 74F413 74F432 74F521 74F524 74F533 74F534 74F538 74F539 74F540 74F540 74F544 74F544 74F544 74F544
HCT00 HCT02 HCT03 HCT04 HCT04 HCT11 HCT11 HCT14 HCT26 HCT27 HCT30 HCT30 HCT32 HCT32	0.22 0.26 0.26 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC10A 74HC10A 74HC10M 74HC13M 74HC20M 74HC30M 74HC32M 74HC32M 74HC35WM 74HC35WM 74HC35WM 74HC123AM 74HC123AM 74HC123AM 74HC123AM 74HC123AM 74HC123AM	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36	74F412 74F413 74F432 74F521 74F524 74F533 74F534 74F538 74F539 74F540 74F540 74F544 74F544 74F544 74F544
HCT00 HCT02 HCT03 HCT04 HCT08 HCT11 HCT11 HCT14 HCT20 HCT21 HCT21 HCT23 HCT30 HCT32 HCT32 HCT34 HCT42 HCT34 HCT44 HCT44 HCT44 HCT44 HCT44 HCT44 HCT44 HCT45 HCT46 HCT73 HCT47 HCT75	0.222 0.22 0.26 0.222 0.22 0.26 0.26 0.2	74HC00M 74HC03M 74HC03M 74HC04M 74HC04M 74HC10A 74HC13M 74HC13M 74HC20M 74HC33M 74HC75M 74HC75M 74HC86M 74HC86M 74HC32M 74HC32AM 74HC132M 74HC132M 74HC132M 74HC132AM 74HC132AM 74HC132M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.46 0.48	74F412 74F413 74F432 74F521 74F524 74F534 74F534 74F536 74F540 74F540 74F540 74F540 74F547 74F547 74F573 74F574 74F574
HCT00 HCT02 HCT03 HCT04 HCT04 HCT01 HCT11 HCT14 HCT27 HCT27 HCT30 HCT27 HCT30 HCT42 HCT42 HCT42 HCT42 HCT42 HCT43 HCT44 HCT45 HCT45	0.22 0.26 0.26 0.22 0.22 0.26 0.26 0.26	74HC02M 74HC03M 74HC03M 74HC03M 74HC104 74HC10M 74HC11M 74HC14M 74HC30M 74HC30M 74HC32M 74HC32M 74HC35M 74HC35M 74HC35M 74HC35M 74HC35M 74HC35M 74HC135M 74HC135M 74HC135M 74HC139M 74HC139M 74HC139M 74HC139M 74HC139M 74HC139M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.46 0.46 0.46 0.46	74F412 74F432 74F432 74F521 74F534 74F534 74F536 74F537 74F537 74F540 74F540 74F545 74F547 74F547 74F547 74F547 74F547 74F573 74F573 74F579 74F604 74F604
HCT00 HCT02 HCT03 HCT04 HCT04 HCT10 HCT11 HCT20 HCT11 HCT27 HCT32 HCT32 HCT32 HCT32 HCT32 HCT32 HCT32 HCT32 HCT32 HCT32 HCT33 HCT35	0.22 0.22 0.26 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC04M 74HC04M 74HC104 74HC104 74HC30M 74HC30M 74HC33M 74HC33M 74HC75M 74HC123AM 74HC123AM 74HC123AM 74HC123AM 74HC133M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC135M 74HC135M 74HC15TM 74HC15TM	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.46 0.46 0.46 0.46 0.46	74F412 74F432 74F521 74F524 74F534 74F534 74F536 74F536 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537 74F537
HCT00 HCT02 HCT03 HCT04 HCT04 HCT04 HCT11 HCT11 HCT11 HCT26 HCT21 HCT30 HCT30 HCT32 HCT32 HCT42 HCT73 HCT73 HCT74 HCT75 HCT85 HCT85 HCT85	0.22 0.22 0.26 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC04M 74HC04M 74HC104M 74HC10M 74HC14M 74HC30M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.48 0.48	74F412 74F432 74F432 74F524 74F524 74F533 74F537 74F538 74F540 74F540 74F540 74F540 74F541 74F544 74F545 74F547 74F574 74
HCT00 HCT02 HCT03 HCT04 HCT04 HCT04 HCT11 HCT11 HCT120 HCT20 HCT20 HCT30 HCT32 HCT32 HCT42 HCT75 HCT75 HCT75 HCT75 HCT93 HCT93 HCT93 HCT93 HCT93 HCT93 HCT93 HCT107 HCT93 HCT107 HCT107 HCT107	0.22 0.22 0.26 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC04M 74HC04M 74HC104M 74HC10M 74HC14M 74HC30M	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.48 0.48	74F412 74F432 74F432 74F521 74F521 74F533 74F534 74F537 74F539 74F540 74F540 74F541 74F544 74F544 74F544 74F547 74F573 74F546 74F547 74F573 74F604
HICT00 HICT02 HICT03 HICT03 HICT01 HICT11 HICT11 HICT11 HICT120 HICT20 HICT30 HICT30 HICT30 HICT30 HICT42 HICT30 HICT42 HICT42 HICT42 HICT45 HICT45 HICT45 HICT65 HICT65 HICT65 HICT65 HICT67 HICT107 HICT107 HICT107 HICT107	0.22 0.22 0.26 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC03M 74HC01M 74HC10H 74HC10H 74HC10H 74HC14M 74HC30M 74HC30M 74HC27A 74HC27A 74HC27A 74HC27A 74HC27A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC37A 74HC38M 74HC37A	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.48 0.48	74F412 74F432 74F432 74F524 74F524 74F533 74F537 74F538 74F540 74F540 74F540 74F540 74F541 74F544 74F545 74F547 74F574 74
HICT00 HICT02 HICT03 HICT08 HICT10 HICT11 HICT14 HICT20 HICT20 HICT20 HICT30 HICT30 HICT30 HICT42 HICT30 HICT42 HICT73 HICT30 HICT65 HICT65 HICT65 HICT65 HICT65 HICT65 HICT67 HICT107 HICT107 HICT107 HICT107 HICT1107	0.22 0.22 0.26 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC03M 74HC10H 74HC10H 74HC10M 74HC10M 74HC20M 74HC20M 74HC20M 74HC20M 74HC20M 74HC20M 74HC23M 74HC33M 74HC133M 74HC133M 74HC133M 74HC133M 74HC135M 74HC135M 74HC135M 74HC135M 74HC135M 74HC157M 7	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.48 0.48 0.48 0.48 0.48 0.57	74F412 74F413 74F432 74F821 74F824 74F533 74F533 74F537 74F537 74F540 74F541 74F547 74F547 74F547 74F573 74F573 74F573 74F646 74F647
HICT00 HICT02 HICT03 HICT03 HICT08 HICT08 HICT11 HICT11 HICT14 HICT27 HICT27 HICT32 HICT32 HICT32 HICT32 HICT33 HICT33 HICT33 HICT33 HICT34 HICT35 HICT165 HICT165 HICT165 HICT167 HICT107 HICT107 HICT107 HICT107 HICT107 HICT123 HICT123 HICT123 HICT123 HICT123	0.22 0.22 0.22 0.22 0.26 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC03M 74HC01M 74HC00M 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC7A 74HC27M 74HC27M 74HC123AM 74HC123AM 74HC132AM 74HC132AM 74HC133M 74HC133M 74HC133M 74HC153M 74HC153M 74HC153M 74HC165M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.48 0.48 0.48 0.48 0.57 0.48 0.48 0.57 0.48 0.57 0.48 0.57	74F412 74F4132 74F432 74F521 74F521 74F524 74F533 74F537 74F537 74F539 74F540 74F540 74F547 74F547 74F573 74F573 74F604 74F647 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621 74F621
HICT00 HICT02 HICT03 HICT03 HICT08 HICT108 HICT11 HICT11 HICT11 HICT12 HICT30 HICT10 HICT110 HICT110 HICT110 HICT112 HICT112	0.22 0.22 0.22 0.22 0.26 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC03M 74HC01M 74HC00M 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC7A 74HC27M 74HC27M 74HC123AM 74HC123AM 74HC132AM 74HC132AM 74HC133M 74HC133M 74HC133M 74HC153M 74HC153M 74HC153M 74HC165M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.46 0.48 0.48 0.48 0.48 0.57 0.48 0.57	74F412 74F413 74F432 74F524 74F524 74F534 74F536 74F537 74F537 74F540 74F540 74F541 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F647
HCT00 HCT02 HCT03 HCT03 HCT08 HCT10 HCT11 HCT11 HCT11 HCT21 HCT21 HCT23 HCT32 HCT32 HCT32 HCT4 HCT93 HCT132 HCT132 HCT14 HCT15 HCT16	0.22 0.22 0.22 0.22 0.26 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC03M 74HC01M 74HC00M 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC7A 74HC27M 74HC27M 74HC123AM 74HC123AM 74HC132AM 74HC132AM 74HC133M 74HC133M 74HC133M 74HC153M 74HC153M 74HC153M 74HC165M	0.32 9.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.48 0.55 0.48 0.55 0.55 0.55	74F412 74F432 74F432 74F521 74F524 74F533 74F533 74F533 74F536 74F537 74F541 74F541 74F545 74F547 74F542 74F547 74F546 74F547 74F647 74
HCT00 HCT02 HCT03 HCT03 HCT08 HCT10 HCT11 HCT11 HCT11 HCT12 HCT30 HCT30 HCT32 HCT32 HCT32 HCT32 HCT73 HCT73 HCT73 HCT73 HCT73 HCT74 HCT75 HCT85 HCT86 HCT93 HCT11 HCT11 HCT112 HCT109 HCT112 HCT109 HCT112 HCT112 HCT112 HCT112 HCT112 HCT137	0,222 0,222 0,222 0,222 0,262 0,262 0,262 0,262 0,462 0,402	74HC00M 74HC03M 74HC03M 74HC03M 74HC03M 74HC06M 74HC14M 74HC10M 74HC14M 74HC20M 74HC24M 74HC27M 74HC27M 74HC27M 74HC27M 74HC27M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC15M 74HC16M 74HC16M 74HC16M 74HC16M 74HC16M 74HC15M 74HC16M 74HC15M 74HC16M 74HC2M 74HC16M 74HC2M 74HC16M 74HC2M	0.32 9.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.48 0.48 0.48 0.48 0.48 0.57 0.48 0.57 0.48 0.57 0.48 0.57 0.48 0.57 0.58 0.58 0.65	74F412 74F413 74F432 74F521 74F524 74F533 74F533 74F536 74F536 74F536 74F540 74F540 74F540 74F547 74F547 74F541 74F541 74F541 74F541 74F541 74F645 74F647 74F647 74F647 74F647 74F647 74F647 74F647 74F647 74F647 74F647 74F647 74F647 74F648
HICT00 HICT02 HICT02 HICT03 HICT04 HICT08 HICT10 HICT11 HICT20 HICT21 HICT20 HICT21 HICT20 HICT30	0.22 0.25 0.26 0.22 0.22 0.26 0.26 0.26 0.26 0.36 0.36 0.40 0.42 0.42 0.43 0.50 0.50 0.50 0.50 0.50	74HC00M 74HC03M 74HC03M 74HC04M 74HC10H 74HC10H 74HC10H 74HC10H 74HC10M 74HC30M 74HC30M 74HC2M 74HC2M 74HC2M 74HC2M 74HC2M 74HC3M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC15M 74HC24M	0.32 9.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.48 0.48 0.57 0.48 0.57 0.48 0.48 0.57 0.48 0.48 0.57 0.48	74F412 74F432 74F432 74F321 74F524 74F534 74F534 74F536 74F536 74F537 74F541 74F541 74F545 74F541 74F546 74F547 74F547 74F547 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT04 HCT08 HCT10 HCT11 HCT26 HCT21 HCT26 HCT21 HCT26 HCT42 HCT42 HCT42 HCT42 HCT42 HCT42 HCT42 HCT42 HCT42 HCT73 HCT66 HCT193 HCT66 HCT193 HCT112 HCT167 HCT107	0.22 0.22 0.22 0.22 0.22 0.22 0.26 0.26	7.4HC00M 7.4HC03M 7.4HC03M 7.4HC03M 7.4HC03M 7.4HC06M 7.4HC14M 7.4HC16M 7.4HC14M 7.4HC20M 7.4HC20M 7.4HC27M 7.4HC27M 7.4HC27M 7.4HC27M 7.4HC138M 7.4HC138M 7.4HC138M 7.4HC138M 7.4HC138M 7.4HC138M 7.4HC138M 7.4HC138M 7.4HC138M 7.4HC158W 7.4HC138M 7.4HC158W 7.4HC258W 7	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.47 0.48 0.57 0.48 0.57 0.59 0.55 0.55 0.55 0.55 0.55 0.55 0.55 0.55 0.55	74F412 74F432 74F432 74F321 74F524 74F534 74F534 74F536 74F536 74F537 74F541 74F541 74F545 74F541 74F546 74F547 74F547 74F547 74F647 74
HCT00 HCT00 HCT01	0.22 0.22 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC10H 74HC10H 74HC10H 74HC10H 74HC10M 74HC30M 74HC30M 74HC2AH 74HC2AH 74HC2AH 74HC2AH 74HC3AH 74HC13AM 74HC13AM 74HC13AM 74HC13AM 74HC13AM 74HC13AM 74HC13AM 74HC13AM 74HC13AM 74HC15AM 74HC24AW 74HC24AW 74HC24AW 74HC24AW 74HC24AW 74HC24AW 74HC24AW 74HC25AW 74HC25AW 74HC25AW 74HC25AW 74HC25AW 74HC25AW 74HC25AW 74HC25AW 74HC25AW 74HC25AW 74HC25AW	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.57 0.38 0.54 0.48 0.57 0.48 0.57 0.48 0.55 0.55 0.55	74F412 74F432 74F432 74F321 74F524 74F533 74F533 74F533 74F536 74F537 74F545 74F545 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F646 74F647 74F646 74F647 74F646 74F647 74F646 74F647 74F646 74F647 74
HCT00 HCT00 HCT01 HCT04 HCT04 HCT04 HCT04 HCT04 HCT06 HCT11 HCT16 HCT16 HCT16 HCT16 HCT16 HCT17 HCT16 HCT17 HCT17 HCT17 HCT17 HCT18	0.22 0.26 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC10H 74HC10H 74HC10H 74HC10H 74HC10H 74HC10H 74HC30M 74HC30M 74HC7A 74HC25M 74HC25M 74HC25M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC135M 74HC135M 74HC15M 74HC24SW 74HC24SW 74HC25M 74HC2	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.46 0.46 0.48 0.55 0.65	74F412 74F4132 74F432 74F524 74F524 74F534 74F536 74F536 74F536 74F536 74F546 74F547 74F546 74F547 74F546 74F547 74F547 74F547 74F547 74F548 74F547 74F548 74F547 74F548 74F547 74F548 74F547 74F548 74F548 74F548 74F646 7
HCT00 HCT00 HCT00 HCT00 HCT00 HCT01 HCT08 HCT01 HCT08 HCT01 HCT10 HCT11 HCT27 HCT12 HCT32 HCT34 HCT109 HCT109 HCT109 HCT109 HCT107 HCT109 HCT108	0.22 0.26 0.26 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC03M 74HC00M 74HC10M 74HC10M 74HC10M 74HC14M 74HC30M 74HC24M 74HC27M 74HC27M 74HC27M 74HC27M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC13M 74HC15M 74HC16M 74HC16M 74HC16M 74HC16M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC15M 74HC25	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.46 0.46 0.48 0.57 0.48 0.57 0.48 0.57 0.48 0.57 0.48 0.57 0.48 0.57 0.48 0.57 0.48 0.57 0.48 0.57 0.55 0.65	74F412 74F413 74F432 74F521 74F524 74F533 74F533 74F533 74F537 74F538 74F540 74F540 74F540 74F540 74F547 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F641 74
HCT00 HCT02 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT07	0.22 0.26 0.26 0.22 0.22 0.26 0.26 0.26	74HC00M 74HC02M 74HC03M 74HC01M 74HC10H 74HC10H 74HC10H 74HC10H 74HC10M 74HC2M 74HC30M 74HC2M 74HC2M 74HC2M 74HC2M 74HC2M 74HC32M 74HC13M 74HC24M 74HC24M 74HC24M 74HC23M 74HC	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.46 0.46 0.48 0.57 0.48 0.57 0.48 0.55 0.65	74F412 74F413 74F413 74F432 74F524 74F524 74F534 74F536 74F536 74F536 74F540 74F541 74F545 74F547 74F547 74F547 74F646 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT01 HCT08 HCT01 HCT08 HCT01 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08	0.22 0.22 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC00M 74HC10M 74HC10M 74HC10M 74HC30M 74HC30M 74HC30M 74HC27M 74HC27M 74HC27M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC136M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC237M 74HC397M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.48 0.48 0.48 0.48 0.57 0.55 0.55 0.55 0.55 0.55 0.55	74F412 74F432 74F432 74F334 74F334 74F534 74F534 74F536 74F536 74F536 74F536 74F537 74F541 74F541 74F641 74F641 74F641 74F641 74F621
HCT00 HCT02 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08	0.22 0.22 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC02M 74HC03M 74HC01M 74HC10H 74HC10H 74HC10H 74HC10H 74HC10M 74HC10M 74HC2M 74HC30M 74HC2M 74HC2M 74HC32M 74HC32M 74HC32M 74HC32M 74HC137M 74HC137M 74HC137M 74HC137M 74HC39M 74HC39M	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.55 0.55 0.65 0.55 0.65 0.65 0.65 0.65	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F547 74F537 74F547 74F547 74F547 74F547 74F548 74F547 74F548 74F547 74F548 74F547 74F548 74F646 74F821 74F848
HCT00 HCT02 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08	0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC10H 74HC10H 74HC10H 74HC10H 74HC10M 74HC30M 74HC30M 74HC23M 74HC23M 74HC23M 74HC23M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC135M 74HC135M 74HC135M 74HC135M 74HC135M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC39M 74HC39M	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.46 0.46 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.49 0.57 0.49 0.55 0.65	74F412 74F413 74F432 74F321 74F524 74F532 74F533 74F533 74F536 74F538 74F536 74F540 74F541 74F545 74F545 74F545 74F547 74F545 74F547 74F547 74F547 74F547 74F548 74F548 74F548 74F548 74F548 74F548 74F548 74F548 74F548 74F646 74F821 74F821 74F821 74F846 74F821 74F846 74F827 74F846 74F827 74F847 74F848 74
HCT00 HCT02 HCT02 HCT02 HCT03 HCT04 HCT08	0.22 0.25 0.22 0.22 0.22 0.26 0.26 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC01M 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC27M 74HC27M 74HC27M 74HC23M 74HC23M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC136M 74HC24SAW 74HC24SAW 74HC24SAW 74HC24SAW 74HC23SAW 74HC23SAW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC3S	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.46 0.46 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.49 0.57 0.49 0.55 0.65	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F536 74F537 74F538 74F537 74F537 74F540 74F540 74F540 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT11 HCT14 HCT14 HCT16 HCT16 HCT16 HCT16 HCT17 HCT17 HCT17 HCT17 HCT17 HCT17 HCT17 HCT18	0.22 0.25 0.22 0.22 0.22 0.26 0.26 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC01M 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC27M 74HC27M 74HC27M 74HC23M 74HC23M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC136M 74HC24SAW 74HC24SAW 74HC24SAW 74HC24SAW 74HC23SAW 74HC23SAW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC3S	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.46 0.46 0.48 0.57 0.48 0.65 0.48 0.65 0.65 0.65 0.65 0.65 0.57 0.53 0.76 0.53	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F537 74F537 74F545 74F547 74F547 74F547 74F547 74F547 74F548 74F547 74F547 74F548 74F547 74F548 74F547 74F548 74F646 74F821 74F646 74F821 74F646 74F821 74F646 74F821 74F646 74F827 74F847 74
HCT00 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT01 HCT18 HCT19 HCT30 HCT31 HCT30 HCT31	0.22 0.25 0.22 0.22 0.22 0.26 0.26 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC01M 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC27M 74HC27M 74HC27M 74HC23M 74HC23M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC136M 74HC24SAW 74HC24SAW 74HC24SAW 74HC24SAW 74HC23SAW 74HC23SAW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC33SW 74HC3S	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.65 0.55 0.55 0.55 0.57 0.76 0.76 0.76 0.76 0.76	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F536 74F537 74F538 74F537 74F537 74F540 74F540 74F540 74F540 74F541 74F641
HCT00 HCT02 HCT02 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT11 HCT14 HCT14 HCT16 HCT16 HCT16 HCT16 HCT17 HCT17 HCT17 HCT17 HCT17 HCT17 HCT17 HCT18 HCT19	0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.22	74HC00M 74HC03M 74HC03M 74HC03M 74HC10H 74HC10H 74HC10M 74HC10M 74HC20M 74HC20M 74HC20M 74HC20M 74HC20M 74HC23M 74HC23M 74HC23M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC132M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC137M 74HC237M 74HC237M 74HC237M 74HC237M 74HC237M 74HC237M 74HC237M 74HC37	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.57 0.48 0.48 0.57 0.48 0.57 0.55 0.65 0.65 0.76 0.76 0.75	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F537 74F545 74F547 74F547 74F547 74F547 74F547 74F547 74F548 74F547 74F547 74F548 74F547 74F548 74F646 74F821 74F846 74F846 74F846 74F846 74F846 74F846 74F846 74F846 74AC00 74AC00 74AC01 74AC01 74AC01 74AC01 74AC02 74AC02 74AC02 74AC02
HCT00 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT07 HCT08 HCT11 HCT18 HCT18 HCT19 HCT30 HCT167 HCT30 HCT167 HCT187 HCT18	0.22 0.25 0.26 0.22 0.26 0.26 0.26 0.26 0.26 0.26	74HC00M 74HC03M 74HC03M 74HC01M 74HC10M 74HC10M 74HC10M 74HC14M 74HC30M 74HC30M 74HC27M 74HC27M 74HC27M 74HC27M 74HC27M 74HC23M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC16M 74HC3M 74HC16M 74HC3M 74HC	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36	74F412 74F432 74F432 74F432 74F534 74F534 74F533 74F533 74F533 74F536 74F537 74F545 74F545 74F547 74F547 74F547 74F547 74F547 74F547 74F548 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT03 HCT03 HCT04 HCT08 HCT08 HCT01 HCT07	0.22 0.22 0.26 0.22 0.22 0.22 0.22 0.22	74HC00M 74HC03M 74HC03M 74HC10H 74HC10H 74HC10M 74HC10M 74HC10M 74HC10M 74HC2M 74HC2M 74HC2M 74HC2M 74HC3M 74HC3M 74HC3M 74HC3M 74HC13M 74HC3	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F545 74F547 74F547 74F547 74F547 74F547 74F548 74F547 74F548 74F547 74F548 74F547 74F548 74F646 74F821 74F846 74F846 74F846 74F846 74F846 74F846 74F846 74F846 74AC010 74AC010 74AC010 74AC017 74AC1017 74AC14 74AC14 74AC14 74AC14 74AC14
HCT00 HCT02 HCT02 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT01 HCT18 HCT19 HCT18 HCT19 HCT19 HCT30 HCT19 HCT30 HCT19 HCT30 HCT19 HCT30 HCT19	0.2220.220.220.220.220.220.220.220.220.	74HC00M 74HC03M 74HC03M 74HC10H 74HC10H 74HC10H 74HC10H 74HC10H 74HC10M 74HC30M 74HC30M 74HC2M 74HC2M 74HC2M 74HC2M 74HC2M 74HC33M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC133M 74HC174H 74HC16M 74HC174M	0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.46 0.46 0.48 0.38 0.48 0.57 0.65 0.65 0.65 0.76	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F537 74F537 74F545 74F545 74F547 74F547 74F546 74F547 74F547 74F547 74F548 74F547 74F548 74F547 74F548 74F648 74
HCT00 HCT02 HCT02 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT01 HCT18	0.222 0.2222 0.22222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.22222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.22222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.22222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.22222 0.222	74HC00M 74HC03M 74HC03M 74HC03M 74HC10H 74HC10H 74HC10M 74HC10M 74HC20M 74HC20M 74HC20M 74HC23M 74HC23M 74HC23M 74HC23M 74HC23M 74HC137M 74HC137M 7	0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.36 0.36	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F545 74F547 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT01 HCT18	0.2220.220.220.220.220.220.220.220.220.	74HC00M 74HC03M 74HC03M 74HC01M 74HC10H 74HC10H 74HC10H 74HC10H 74HC10M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC13M 74HC3M 7	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.48 0.48 0.48 0.49 0.55 0.55 0.55 0.55 0.55 0.55 0.55 0.5	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F545 74F547 74F647 74
HCT00 HCT00 HCT00 HCT01 HCT02 HCT03 HCT01 HCT02 HCT03	0.222 0.2222 0.22222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.22222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.22222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.22222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.2222 0.22222 0.222	74HC00M 74HC03M 74HC03M 74HC03M 74HC03M 74HC10H 74HC10H 74HC10M 74HC10M 74HC10M 74HC20M 74HC20M 74HC20M 74HC23M 74HC23M 74HC23M 74HC23M 74HC3SM 74HC13SM 74HC3SM 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.48 0.48 0.48 0.49 0.55 0.55 0.55 0.55 0.55 0.55 0.55 0.5	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F536 74F537 74F536 74F546 74F547 74F547 74F547 74F546 74F547 74F547 74F546 74F547 74F547 74F548 74F547 74F548 74F646 74F724 74F646 74F724 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT01 HCT08 HCT01 HCT07 HCT08	0.2220.220.220.220.220.220.220.220.220.	74H-C00M 74H-C03M 74H-C03M 74H-C03M 74H-C03M 74H-C10M 74H-C10M 74H-C10M 74H-C10M 74H-C10M 74H-C20M 74H	0.32 0.32 0.32 0.32 0.32 0.32 0.32 0.32	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F537 74F538 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F547 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT08 HCT08 HCT08 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08	0.2220.220.220.220.220.220.220.220.220.	74HC00M 74HC03M 74HC03M 74HC03M 74HC03M 74HC10H 74HC13M 74HC17M 74HC15M 74HC17M 74HC17	0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.36 0.36 0.46 0.48 0.48 0.48 0.49 0.55 0.55 0.55 0.55 0.55 0.55 0.55 0.5	74F412 74F412 74F412 74F412 74F412 74F412 74F412 74F412 74F413 74F413 74F534 74F538 74F536 74F536 74F536 74F546 74F547 74F546 74F547 74F546 74F547 74F546 74F547 74F546 74F547 74F548 74F548 74F646 74F821 74F646 74F746 74F646 74F746 74F646 74F746 74F646 74F746 74F646 74F746 74F646 74F746 74F746 74F746 74AC019
HCT00 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT01 HCT08 HCT07 HCT08	0.2220.220.220.220.220.220.220.220.220.	74HC00M 74HC03M 74HC03M 74HC03M 74HC03M 74HC10H 74HC10H 74HC10M 74HC10M 74HC20M 74HC20M 74HC20M 74HC23M 74HC23M 74HC23M 74HC23M 74HC23M 74HC32M 74HC32M 74HC32M 74HC32M 74HC32M 74HC13ZM 74HC12ZM 74HC13ZM 74HC12ZM 74HC12ZM 74HC12ZM 74HC12ZM 74HC12ZM 74HC12Z	0.32 0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.48 0.48 0.55 0.55 0.65 0.66 0.66 0.78 0.55 0.66 0.78 0.55 0.66 0.78	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F536 74F537 74F538 74F537 74F538 74F540 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F646 74F646 74F647 74F641 74F646 74F646 74F646 74F646 74F646 74F646 74F646 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT01 HCT08 HCT01 HCT08 HCT01 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08	0.222 0.2222 0.22222 0.2222	74HC00M 74HC10M 74HC2M 74HC3M 74HC13M 74HC2M 74HC3M 7	0.32 0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.48 0.48 0.55 0.55 0.65 0.66 0.66 0.78 0.55 0.66 0.78 0.55 0.66 0.78	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F536 74F537 74F538 74F537 74F538 74F540 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F646 74F646 74F647 74F641 74F646 74F646 74F646 74F646 74F646 74F646 74F646 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT03 HCT03 HCT04 HCT08 HCT01 HCT08 HCT01 HCT01 HCT01 HCT01 HCT01 HCT01 HCT01 HCT02 HCT03	0.2220.220.220.220.220.220.220.220.220.	74HC00M 74HC03M 74HC03M 74HC03M 74HC03M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC20M 74HC23M 74HC23M 74HC23M 74HC23M 74HC23M 74HC13SM 74HC13SM 74HC13SM 74HC13SM 74HC13SM 74HC13SM 74HC15SM 74HC24GM 74HC24GM 74HC24GM 74HC24GM 74HC24GM 74HC24GM 74HC24GM 74HC25GM 74HC25GM 74HC26GM 74HC26GM 74HC26GM 74HC26GM 74HC2GM 74HC3GM 74HC3G	0.32 0.32 0.32 0.32 0.32 0.32 0.36 0.36 0.36 0.36 0.46 0.48 0.48 0.55 0.55 0.65 0.66 0.66 0.78 0.55 0.66 0.78 0.55 0.66 0.78	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F536 74F537 74F538 74F537 74F538 74F540 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F541 74F646 74F646 74F647 74F641 74F646 74F646 74F646 74F646 74F646 74F646 74F646 74F647 74
HCT00 HCT02 HCT02 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT01 HCT08 HCT01 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08	0.2220.220.220.220.220.220.220.220.220.	74HC00M 74HC10M 74HC2M 74HC2M 74HC2M 74HC2M 74HC2M 74HC2M 74HC2M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC3M 74HC13M 74HC2M 74HC3M 74H	0.32 0.32 0.32 0.32 0.32 0.32 0.32 0.32	74F412 74F412 74F412 74F412 74F412 74F412 74F412 74F412 74F524 74F534 74F536 74F536 74F536 74F537 74F538 74F541 74F646 74F646 74F646 74F647 74
HCT00 HCT02 HCT02 HCT03	0.2220.220.220.220.220.220.220.220.220.	74HC00M 74HC03M 74HC03M 74HC03M 74HC03M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC20M 74HC23M 74HC23M 74HC23M 74HC23M 74HC23M 74HC13M 74HC1M	0.32 0.32 0.32 0.32 0.32 0.32 0.32 0.32	74F412 74F413 74F413 74F534 74F538 74F538 74F536 74F541 74F641 74
HCT00 HCT02 HCT02 HCT03 HCT04 HCT08 HCT08 HCT08 HCT08 HCT08 HCT01 HCT08 HCT01 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08 HCT07 HCT08	0.22 0.26 0.26 0.26 0.26 0.26 0.26 0.26	74HC00M 74HC10M 74HC2M 74HC2M 74HC2M 74HC2M 74HC2M 74HC3M 74HC13M 74HC2M 74HC3M 74	0.32 0.32 0.32 0.32 0.32 0.32 0.32 0.32	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F536 74F537 74F538 74F537 74F538 74F547 74F647 74
HCT00 HCT02 HCT02 HCT03	0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.22	74HC00M 74HC03M 74HC03M 74HC03M 74HC01M 74HC10H 74HC10H 74HC10H 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC10M 74HC2M 74HC2M 74HC2M 74HC2M 74HC2M 74HC3M 74HC3M 74HC3M 74HC3M 74HC13M 74HC1M 74HC1M 74HC1M 74HC1M 74H	0.32 0.32 0.32 0.32 0.32 0.32 0.32 0.32	74F412 74F432 74F432 74F432 74F534 74F534 74F536 74F536 74F537 74F538 74F537 74F537 74F545 74F547 74

	1.10 1.10 1.28 1.28	74C73 74C74	1.28 0.94	1N2986RB	18 2
	1.28	74C76	1.26	1N3881 1N3997A	2.5 6.5
	1.28	74CB5	1.26	1N4001	0.0
	4.92	74C85 74C90 74C93 74C95 74C150 74C151	1.29 2.10	1N4002	0.0
	4.48	74093	1 60		0.0
	3.60	74C95 74C150 74C151 74C154 74C154 74C165 74C165 74C221 74C221 74C240 74C244 74C373 74C90° 74C90°	5.401	1N4006 1N4007	0.0
	0.76	74C151	3.94 5.82 3.80	1N4*48	0.0
	4.48	740154	3.00	1N4149	0.0
	1 80	74C164	2.54	1N4150 1N4446	0.0
	4 98	74C165	2.54	1N4728A	0.2
	3.40	74C221	2.98		0.2
	3.20	74C240	2 08 2.08 2.08	1N4736A	0.2
	3.20	74C244	2.08	1N4740A	0.2
	1.48	74C374	2.08	1N4743A 1N4744A	0.2
	2.24	74C90° 74C902	1 18	1M4758A	0.2
	4.38	740902	1.18	1N5226B	0.0
	0.62	74C903	1.10	1N5232B	0.0
	0.62	74C907	1.18 1.52 1.10 1.10	1N52348	0.05
	0.62	740908		1N5337B 1N5349B	0.4
	0.72	740911	4 42	1N5352B	0.4
	0.66	74C912	14.42	1N53578	0.4
	0.62	74C915	1.16	1N5365B	0.41
	0.62	74C922	6.80	1N5366B 1N5370B	0.4
	0.66	74C90* 74C902 74C903 74C906 74C906 74C907 74C908 74C911 74C912 74C914 74C915 74C922 74C923 74C925	6.80 6.80	1N5380B	0.4
	POA	74C923 74C925 74C926 74C929 74S SER	9.30 9.30 9.30	48/E 101	0.1
	0.78	740926	9.30	*N5402	0.1
	7.48	74S SER	IES	1N6287A 1N825	1.55
			5 7	1N825A	1.3
	0.68	74S00	0.44	1N827	1.4
	0.68 0.92 POA POA 1.50	74502 74503	0.44	188252	0.2
	POA	74S03	0.42	5082-2800 5082-2810	
	1.50	74808	0.51 0.42 0.42 0.48	5082-2815	0.4
	1.14	74808 74809 74810 74811 74820 74832 74840 74851 74864	0.48	AA119	0.66
	1 28	745'0	0.98	AA144	0.73
	1 30	7451	0.48	AAZ15	0.50
	1.48	74532	0.78	AAZ17 AAZ18 BAV10	0.4
	1.30	74S40	0.25	BAV10	0.0
	0.62	74851	0.36	BAVAS	49
	0.92	74564	0.36	BAW62 BAX16 BB204 BB212	0.0
	1.56	74586	1.12	BB204	0.00 0.30
	3.68 POA	74S74 74S86 74S112 74S124 74S132	1.08	88212	0.3 2.4
	POA	74\$124			0.2
	0.98	745133	0.73	BB809 BV179	0.6
	POA	740.04	1.95	BY260 200	3.5
	POA POA 1.20	745138	0.88	BB403B BB809 BY179 BY260 200 BY261-200 BYV28-100 BYV37-50	3.9
	1.20	74S139 74S140	0.88	BYV28-100	0.9
	POA	748153	1.26	CVRR05	0.6
	1.20	74S157	1.72	DS16C MV1404 MV209 OA200 OA202 OA47	0.4
	1.20	74S163	2.60	MV1404	15 9
	1.60	74S174 74S175	0.92	MV209	12
	1.60	74S182	3.29	OA200 OA202	0.1 0.2
	1 98	74S189	2.14	OA47	0.1
	1.98 3.98	748195	2 40 1 00 1.12	OA90	0.1
	DOW	748240	1 00	P6KE36A	0.8
	POA	74S241 74S244	1.77	P6KE47A REC53A	0.4
	POA	748257	1.22	ZPD2.7V	0.0
	POA POA 2.92 2.92	74S25B	1 22	ZPD2.7V	
	7.598	-40mma	0.70	ZENER DI	
	4.84	745274	2.44	MISC	
	POA	745280		BZY93C7V	5 2.6
	4.84 POA POA POA	74S283	1.90	BZY93C15	2.6
	5 15		2.18	BZY93C18	R2.6
	POA	7453394	2.10	BZY93U20	2.5
	3 98	745436	2.62	BZY93C33	H2.6
	POA	745394 745412 745436 745437	2 62	BZY93C7V BZY93C15 BZY93C20 BZY93C24 BZY93C33 BZT03C12V BZX61C9V BZX61C9V	0.4
	4.48	74S472 74S734	2 32	BZX61C9V	200
	4 48	140104	2.02	ZENER DI	ODES
	4.93 POA	VOLTAG REGULAT	GE ORS	400m\	٧
	3 75	REGULAT	OHS	2.4V to 75V	
		78008AP	1.15	Price: 6p ea	ach
Ξ	RIES	7805	0.28	ZENER DI	nes
	0.38	7805A	0.32	500m\	
	0.49	7805FA 7806	0.32 0.45 0.28 0.28	2.4V to 200	W
	0.40	7808	0.28	Price: 6p ea	ıch
	0.40	7809	0.32	ZENER DI	nne
	0.40	7812	0.32	1.3 WA	
	0.40 0.40 0.40 0.40	7812A 7812CTC	0.32	2.7V to 200	N
	0.40	7815	0.32 0.28	Price:10p e	ach
	0.40	78:B	0.28		one
	0.48	78:8 7824 78L05 78L05A	0.28	ZENER DI	
	0.81	78L05A	0.28		W
	0.65	78L05A 78L05ACLI 78L05ACZ	P0.40	Price:40p a	ach
	0.65	78L05ACZ	0.28	ZENER DIC 5.0 WA	DES
	0.65	78L12 78L124	0.28		
	0.81	78L05ACL1 78L05ACZ 78L12 78L12A 78L12ACZ 78L15 78L24	0.30	Price 42p e	
	0.65	78L15	0.2B		
	0.80	78L24	0.28	STUD MO	
	0.65	78L56 78M05	0.32	20 WA	
	0.80	WORKSON A	0.36	7,5V to 75	V
	1.38	701412	0.28 1 10 0 32 0.36 0.32	Price: £4.94	t ea.
	0.92	78M12A	0.36	BRIDG	F
	0.92	78M13A 78M15	0.65	RECTIFIE	
	1.10	78S05	0.48		
				ELEI	ZT

74AC258 74AC273 74AC283 74AC299 74AC373 74AC377 74AC377

74AC541

74AC573 74AC574 74AC646 74AC648

74C00 74C02 74C08 74C10 74C14 74C20 74C30 74C32 74C42 74C48 74C73 74C74 74C76 74C85

udverti	isei	3					
78S12 78S15	0.48	0.9A/200VDIL 3.0A/200V SIL	0.38	Freq MHz 3.6864,4,8,10,12	16	KM44C256AZ-11	
7905 7905A	0.32	6A/100V SIL 8A/200V SIL	*.60	20.24,32,40 & 5t Price: £4.20 eac)	M5M44B4P 15 MK4116N-54	2
7905FA	0.60	35A/100V Sqr	2.98			MK4564N-15 NMC3764N-15	1
7909 7912	0.55	KBPC1002 KBPC3502	1 64 2.98	TTL Output 14pin DIL Layo	out	UPD41464G-12 UPD41464G-15	4
7912A 7912FA	0.78	W005 1A/50\ 0.32	/	Sealed Meta 4pin Pkg	l.	UPD416C-2 UPD416C-3	3
7915 7918	0.30 0.30	W02G- 1.5A 2W02	0.40	Freq. = MHz 1MHz £8.90 ea.		UPD446D-1	2
7924 79L12A	0.30	2KBB10R/SIL 2KBB20R/SIL	0.66	4.4.9152 6.8.9.8		STATIC RA	М
79L12ACP	0.35	B80C1500/Sq	0.35	10 12.15.16,		2114-3L	3
79M05 79M05A	0 42	B80C1500SIL SKB6008/60A		-8.432, 19.6608 20, 24, 25 & 30N	1Hz	6264LP 10 6264LP 12	2
79M05FA 79M12	0.65	CRYSTAL	s	Price: £3.52 ea.		62256LP-12 62256LP-10	4
79M12A LM317T	0.60	HC49(HC18	(U)	30, 32, 32,768, 33,33,40 & 50M	Hz	CDM6116AE3	5
LM317MP EM317LZ	1.06	Freq.MHz 1.B43200	1.60	Price: £4.45 ea.		CDM6117AE3 HM1-6116-5	5
LM338K	4.45	2.000000 2.457600	- 66 - 49	Programmabi	le	HM3-6116-5 HM6116LP-2	2
UA78GU1C UA79GU1C	1.02	3.276800 3.579545	0.98	Crystal Oscillators		HM6116LP 3 HM6117LP-3	5
RC4195N DIODE	1.80	3 686400	1 02	EXO-3C SERIE	s	HM62256LP-10 HM6264ALP-12	7
ALCO CARLES		4.096000	1.10 1.10	8pin DIL Plast Package	ic	HM6264ASP-20	3
1N2986RB 1N3881	2.54	4.194304	1.10	Freq MHz	. 1	HM6267P-35 HM628128LP-80	
1N3997A 1N4001	6.55	4 608000	1.10	12 14 31818, 16 16.384,19.6608	3	HM66204L 12	18
1N4002 1N4003	0.04	5.000000/S	1.02	20MHz Price: £3.92 ea.		KM62256ALP-10 LH5164D-10L	
1N4006	0.04	5.068800 5.242880	1.10	16pin DIL Plas	tic	P2" 14AL-2	3
1N4067 1N4148	0.04	5.888200 6.000000	1.80	Package Programmable		P2114AL 4 PCD5101P	3
1N4149 1N4150	0.06 0.08	6.144000 6.400000	1 64	57 Diff,Frequer		UPD43256AGU1	IOL B
1N4446 1N4728A		6.552000	1.40	SPG8640AN		UPD43256C-12 UPD4364C-15	5
1N4735A	0.24	6.553600 7.372800	1.21 0.78	0.005 to 600kHz			
1N4736A 1N4740A	0.24	8.900000 8.867230	1.00	SPG8640BN		UVPROMS	1
1N4743A 1N4744A	0.24	9.830400	1 20	0 0083 to 1MHz		27C128-25 27C64A-15	3
1N4756A	0.24	10.00000 10.69500	7.10 1.90	SPG864UCN 0.064 to 768kHz	6	27C256-15	3
1N5226B 1N5232B	0.09	12.00000	1.10	SPG8650BN		27C256 25 D27256	5
1N52348 1N5337B	0.09	13 87500	2.40	0.00083 to 100k	Hz	27C512D-12 27C1000D 12	6 8
1N5349B 1N5352B	0.48	14.31818/S	0.85	Price: £ 9.25 ea		27C4096-12 HM27C101G-20	9
1N53578	0.48	14.74560/S 14.74560	1.10	DC to DC		HN27C1024HG1	0
1N5365B 1N5366B	D.48	*5.00000/S 15.00000	1 10	Converters		HN27C64FP-201	, g
1N5370B 1N5380B	0.48	16.00000/S 18.43200/S	1.20	3W5R 15:15 2	5 60 7.50	HN27C64G 15 HN27C64G-20	4
1N5401 *N5402	0 11	19.66080/S	1.20	IPL S.010 2	3.40	HN482532P HN4827128G-25	4
1N6287A	1.55	20.00000/S 22.11840/S	1.68 1.68	1 Watt DC/Dt		HN482764G	3
1N825 1N825A	1.34	24.00000/S 27.64800/S	1.82	DIL & SIL by		M2716-1F1 M5L2732K	3
1N827 1SS252	1.40	30 00000/S 32 00000/S	6.99	Newport NMA0505±5V		M51,2764K MBM27C64-20/2	3
5082-2800	0.66	48.00000/S	1.58	NMA0509±9V NMA0512-12V			4
5082-2810 5082-2835	0.44	S = Series		NMA0515+15V		MBM27C128-30 MBM27C256-30	5
AA119 AA144	0.60	HC33:U		Price:£7.90ea.		NMC27C256Q 2	5 4
AAZ15 AAZ17	0.58	0.204800 0.307200	8 23 6 99	DC/DC Conver by Compute	ters r	NMC27C64Q-25 TMS2516JL-45	4
AAZ18 BAV10	0.48	1.000000	3.95	Products PM623 2	4 60	TMS27128.IL-25	4
BAV45	4 98	2 000000 2 097152	4.65	PM671 2	6 70	UPD272560/21V	
BAW62 BAX16	0.06	2.457600	1 92	PM903 4	6.70 4.00	UPD2732A:21V UPD27C256U 1:	5 5
BB204 BB212	D.32 2.48	2.500000 3.000000	1.92 2.25	PM951 4	6.50	UPD27C512D-1: UPD27C64D-25	5 5
BB405B BB809	0.22	HC49/U4F	4	STATE OF STREET		EEPROMS	
BY179	0.42	3.276800	1.66	METAL FILM 0.25W 1%	1		
BY260 200 BY261-200	3 98	3.579545 5.068800	1.58 2.25	E24 Series 10R to 1M 3p e	ach	28C64-25 28C64-15	10
BYV28-100 BYV32-50	0.99	7 864320	1 49	N.B. Min Oty Or Min Spes pur va		28C256-20 28C256-15	25
CVBB05 DS16C	0.60	8.000000 10.00000	1.14 2.25	METAL FILM			
MV1404	15 90	11.05920	2.40			28G256-15DG	28
MV209 OA200	0.10	14,00000		PRECISION	1	X2816AD X2816AP-25	5
OA202 OA47		16 000000	2.25	0.25 WATT 0.1	1	X2816AD	5
DA90	0.14	16.00000 20.00000	2.25 1.14 1.52	PRECISION 0.25 WATT 0.1 E96 Series 100R to 255K	1%	X2816AD X2816AP-25 X2864AP-35	5 12
G. 100	0.14	20.00000 24.00000	2.25	PRECISION 0.25 WATT 0.1 E96 Series 100H to 255K Price: £0.94 eac	1% :h	X2816AD X2816AP-25 X2864AP-35 24C01 24C02 24C04 24C16	5 12 1 2 2 5
P6KE36A P6KE47A	0.14 0.14 0.88 0.88	20.00000 24.00000 UM-1	2.25 1.14 1.52 1.90	PRECISION 0.25 WATT 0.1 E96 Series 100P to 255K Price: £0.94 eac HIGH PRECISI NON-INDUCTI	h ON VE	X2816AD X2816AP-25 X2864AP-35 24C01 24C02 24C04 24C16 28C04A-20 59C11	5 12 1 2 2 5 4
P6KE36A	0.14 0.14 0.88	20.00000 24.00000 UM-1 8.000000	2.25 1.14 1.52	PRECISION 0.25 WATT 0.1 E96 Series 100Ft to 255K Price: £0.94 eac HIGH PRECISI	h ON VE D	X2816AD X2816AP-25 X2864AP-35 24C01 24C02 24C04 24C16 28C04A-20	5 12 1 2 2 5 4
P6KE36A P6KE47A REG53A ZPD2.7V	0.14 0.14 0.88 0.88 0.40 0.06	20.00000 24.00000 UM-1 8.000000 8.192000 10.00000	2.25 1.14 1.52 1.90 2.25 2.02 2.25	PRECISION 0.25 WATT 0.1 E96 Series 100H to 255K Price: £0.94 eac HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.1	on VE D	X2816AD X2816AP-25 X2864AP-35 24C01 24C02 24C04 24C16 28C04A-20 59C11 93C46	5 5 12 1 2 2 5 4 1 1
P6KE36A P6KE47A REC53A	0.14 0.88 0.88 0.40 0.06	20.00000 24.00000 UM-1 8.000000 8.192000 10.00000 11.00000 12.28800	2.25 1.14 1.52 1.90 2.25 2.02 2.25 2.25 2.66	PRECISION 0.25 WATT 0.1 E96 Series 100H to 255K Price: £0.94 eac HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.1 Temp Coeff.3p 10R.50R 100R.2	on VE D	X2816AD X2816AP-25 X2816AP-35 24C01 24C02 24C04 24C16 28C04A-20 55C11 93C06 93C46 MISC. MEMOR	5 12 1 2 2 5 4 1 1 1
P6KE36A P6KE47A REC53A ZPD2.7V ZENER DIC MISC. BZY93C7V	0.14 0.88 0.88 0.40 0.06 DDES	20.00000 24.00000 UM-1 8.000000 8.192000 10.00000 11.00000 12.28800 15.00000 17.73447	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATT 0.1 E96 Series 100R to 255K Price: £0.94 eac HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.1 Temp Coeft.3p 10R,50R 100R,21 10K,100K	on VE D I%	X2816AD X2816AP-26 X2864AP-25 X2864AP-35 24C01 24C04 24C04 94C04 98C01 99C06 93C06 93C46 MISC. MEMOS 6341-1J AM2*48-45DC	5 5 12 1 2 2 5 4 1 1 1 1 1 1
P6KE36A P6KE47A REC53A ZPD2.7V ZENER DIC MISC. BZY93C7V BZY93C15 BZY93C16B	0.14 0.88 0.88 0.40 0.06 DDES 52.66 2.66 R2.66	20.00000 24.00000 UM-1 8.000000 8.192000 10.00000 11.00000 12.28800 15.00000	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.66 2.25	PRECISION 0.25 WATT 0.1 E96 Series 100R to 255K Price: £0.94 eac HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.1 Temp Coeft.3p 10R,50R 100R,21 10K,100K	on VE D I%	X2816AD X2816AP.26 X2864AP.35 24C01 24C02 24C02 24C04 24C16 28C04A-20 59C11 93C06 93C46 MISC. MEMOR 6341-1J	5 5 12 1 2 2 5 4 1 1 1 1 1 1 8 1 8
P6KE36A P6KE47A REC53A ZPD2.7V ZENER DIC MISC. BZY93C7V BZY93C18 BZY93C18 BZY93C20	0.14 0.18 0.88 0.40 0.06 DES 52.66 2.66 2.66 2.66	20.00000 24.00000 UM-1 8.000000 8.192000 10.00000 11.00000 12.28800 15.00000 17.73447 18.00000 21.00000 21.00000	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.80 2.50 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATT 0.1 E96 Series 100F to 255K Price: 60.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.015 WATT 0.15 (10K, 10K) Price: \$2.85 eac HIGH PRECISI NON-INDUCTI	on ve D %	X2816AD X2816AD 25 X2864AP-25 X2864AP-25 X2864AP-35 24C01 24C04 24C04-20 59C11 93C06 93C-16 6341-1J AM2-148-45DC AM275281PC ID 1713GLA-1001	5 5 12 2 2 5 4 1 1 1 1 7 8 1 8 1 8 1 9 1 9 1 9 1 9 1 9 1 9 1 9 1
P6KE36A P6KE47A P6C53A ZPD2.7V ZENER DIC MISC. BZY93C7V BZY93C15 BZY93C24 BZY93C24 BZY93C24 BZY93C33	0.14 0.88 0.80 0.40 0.06 0.06 0.06 0.06 2.66 2.66 2.66 2.6	20.00000 24.00000 UM-1 8.000000 8.192000 10.00000 12.28800 15.00000 17.73447 18.00000 21.00000 24.00000	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.26 2.25 2.25 2.25 2.25	PRECISION 0.25 WATT 0.1 E96 Series 100H to 255K Price: £0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.1 Temp Coeff.3p 10K,150K Price: £3.85 eac HIGH PRECISI	ON VE D SOR	X2816AD X2816AP-25 X2864AP-35 24C01 24C02 24C04 24C04 24C04 24C16 28C04A-20 59C11 93C06 93C46 MISC. MEMOR 6341-1J AM2*48-45DC AM275281 PC ID T713OLA-1000 IDT7132LA 1001	5 12 2 2 2 5 4 1 1 1 1 5 3 P P P P
P6KE36A P6KE47A REC53A ZPD2.7V ZENER DK MISC. BZY93C7V BZY93C15 BZY93C20 BZY93C20 BZY93C20 BZY93C33 BZT03C12C BZY61C9V	0.14 0.88 0.80 0.06 0.06 0.06 0.06 0.06 0.06	20,00000 24,00000 UM-1 8,000000 8,192000 10,00000 11,00000 11,00000 15,00000 15,00000 21,00000 24,00000 CRYSTALS M	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.26 2.25 2.25 2.25 2.25	PRECISION 0.25 WATT 0.1 E98 Series 100P to 255K Price: C0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOOD 0.15 WATT 0.1 Temp Coeft.39 Frice: S3.85 eac HIGH PRECISI NON-INDUCTI WIRE WOUN 0.33 WATT 0.1 Temp Coeft.39 Temp Coeft.39	th ON VE D SOON ON VE D SO SOON ON VE D SO SOON ON SOON SOON SOON SOON SOON S	X2816AD X2816AP-25 X2864AP-35 24C01 24C02 24C04 24C04 24C16 28C04A-20 59C11 193C06 93C46 MISC. MEMOI 6341-1J AM2*48-45DC AM27S981PC IDT7133LA-1001 IDT7133LA-1001 MIB4-14E MCM4097AC3	5 5 12 2 2 5 4 4 1 1 1 1 1 5 3 P P P P 4 2
P6KE36A P6KE47A P6C54A ZPD2.7V ZENER DK MISC. BZY93C79 BZY93C16 BZY93C20 BZY93C24 BZY93C24 BZY93C30 BZY63C12 BZX61C244 ZENER DK	0.14 0.88 0.80 0.06 0.06 0.06 2.66 2.66 2.66 2.66 2.6	20.00000 24.00000 UM-1 8.000000 8.192000 10.00000 12.28800 15.00000 17.73447 18.00000 21.00000 24.00000	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.26 2.25 2.25 2.25 2.25	PRECISION 0.25 WATT 0.1 E98 Series 100B to 255 K Price: £0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.1 Temp Coeff.3p 10K,100K Price: £3.85 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.33 WATT 0.13 WATT 0.13 WATT 0.13 WATT 0.13 WATT 0.13 WATT 0.13 WATT 0.15 W	on on the control of	X2816AD X2816AD X2816AP-25 X2864AP-35 24C01 24C02 24C04 94C16 28C04A-20 59C11 93C06 93C46 MISC. MEMOR 6341-1J AM2 48-45DC AM275281 PC ID F713CIA-1001 IDT713ZIA-1001 IDT713ZIA-1001 N828153N N828153N	5 5 12 2 2 2 5 5 4 1 1 1 1 1 1 1 5 3 2 P P P P 4
P6KE36A P6KE47A P6Ce34A ZPD2.7V ZENER DIC MISC. BZY93C79 BZY93C20 BZY93C20 BZY93C20 BZY93C3 BZY93C3 BZY9	0.14 0.88 0.80 0.06 DES 52.66 2.66 2.66 2.66 2.66 2.66 0.40 2.09 0.40 0.09 0.09	20,0000 24,00000 UM-1 8,000000 8,192000 10,00000 11,00000 11,00000 15,00000 15,00000 21,00000 21,00000 CRYSTALS N HC43/T 1,000000 MINI CYLINDR	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATTO: E98 Series 100 Pto 255 K Price: £0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATTO: 10K,100 K Price: £3.85 aar HIGH PRECISI NON-INDUCTI WIRE WOUN 0.33 WATTO: Temp Coeff.39 Temp Coeff.39 Temp Coeff.39 Price: £3.60 ear	on ve D %	X2816AD X2816AD X2816AP 25 X2864AP 35 24001 24002 24004 24016 28004A-20 59011 93006 93046 MISC. MEMOR 6341-1J AM2 48-45DC AM275981PC ID F7130LA-1001 IDT7132LA 1001 MIB84*4E MCM4027AG3 N82S156AN N82S153N N82S15N N82S15N N82S15N N82S15N N82S15N N82S1N N82S1	5 5 12 2 2 2 2 5 4 1 1 1 1 5 3 P P P P P P P P P P P P P P P P P P
P6KE36A P6KE47A P6C54A ZPD2.7V ZENER DK MISC. BZY93C79 BZY93C16 BZY93C20 BZY93C24 BZY93C24 BZY93C30 BZY63C12 BZX61C244 ZENER DK	0.14 0.14 0.88 0.40 0.06 0.06 0.06 0.06 0.06 0.06 0.06	24.00000 24.00000 UM-1 8.000000 8.192000 11.00000 11.00000 11.00000 11.00000 12.00000 17.73447 18.00000 24.00000 CRYSTALS N HC43/T 1.000000 MINI CYLINDI 0.032768	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WAT 0.1 E98 Series 100 Pt 0.25 WAT 0.1 E98 Series 10.09 to 255 WAT 0.1 Temp Coeff. 39 10R, 50R 1	ON VE D SOR Ch	X2816AD X2816AD X2816AP 25 X286AAP 35 24001 24002 24004 24016 28004A-20 59011 99006 93046 MISC. MEMOF 6341-1J AM2 48-45DC AM275981PC ID 17130LA-1001 IDT7132LA 1001 MB8414E MCM4027AG3 N825156AN N825156AN N825153N NMC9504J9 NMC9306N	5 12 1 2 2 5 4 1 1 1 1 5 3 P P P P 4 2 2 2 5 6 3 1 1
P6KE36A P6KE47A RECS3A ZPD2.7V ZENER DK MISC. BZY93G7V BZY93C78 BZY93G20	0.14 0.18 0.88 0.40 0.06 2.66 2.66 2.66 2.66 0.040 0.040 0.040 0.040 0.040 0.040 0.040 0.040 0.040 0.040 0.040 0.040 0.040 0.040	20,0000 24,00000 UM-1 8,000000 8,192000 10,00000 11,00000 11,00000 15,00000 15,00000 21,00000 21,00000 CRYSTALS N HC43/T 1,000000 MINI CYLINDR	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATT 0.1 E98 Series 100B to 255 K Price: £0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.15 WATT 0.1 Temp Coeft.39 Price: £3.85 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATT 0.1 Temp Coeft.39 Price: £3.80 Pr	ON VE D % PPM 650R	X2816AD X2816AD X2816AP 25 X286AAP 35 24001 24002 24104 24104 24106 2800A-20 59011 99006 993C46 MISC. MEMOR 6341-1J AM2 48-45DC AM275981PC ID I77130LA-1001 IDT7132LA 1001 MIBRA-4E MCLM0972AC3 N22S126AN N2SS153N NMCS504J9 NMCS506N P510*L-1*TEP*18S050N	5 5 12 2 2 2 5 5 4 1 1 1 1 5 3 P P P P 4 2 2 2 5 6 6 3 1 1 3 1
PBKE36A PBKE36A PBKE47A PBCC33A ZPD2.7V ZENER DK MISC. BZY93C7V BZY93C18 BZY93C20 BZY93C24 BZY93C24 BZY93C31 BZY93C31 BZY93C31 BZY93C34 BZY93C3A BZY93C3A BZY93C3A BZY93C3A BZY93C3A BZY93C3A BZY93C3A BZY93C3A BZY93C3A	0.14 0.14 0.88 0.40 0.06 2.66 2.66 V.2.68 V.2.68 V.2.00 V.0.09 V.0.09 V.0.09 V.0.09 V.0.09 V.0.09 V.0.09 V.0.00 V.000 V.0	24.00000 24.00000 UM-1 8.000000 8.192000 11.00000 11.00000 11.00000 11.00000 11.00000 11.00000 12.00000 15.00000 15.00000 CRYSTALS N HC43/T 1.000000 MINIC CYLINDI 0.032768 WATCH 0.032768 CRYSTAL	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.80 2.25 2.80 2.25 2.80 8.80 8.80 8.80 8.80 8.80 8.80 8.80	PRECISION 0.25 WAT 10.00 H to 25 M k Price: \$2.00 H ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.15 WATT 0.1 Temp Coeff.3p Price: \$2.3 85 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATT 0.1 Temp Coeff.3p Price: \$2.3 85 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATT 0.1 Temp Coeff.3p Price: \$2.3 65 ear 10.00 H lb 10.	ON VE D IS DON SOR D IS D I	X2816AD X2816AD X2816AP 25 X286AAP 35 24001 24002 24104 2416 2810AA-20 580C11 93006 930C46 MISC. MEMOR 6341-1J AM2 48-45DC AM275981PC 1D 17130LA-1001 1D77132LA 1001 MIBA1-4E MCLM0273C3 N82S126AN N82S126AN N82S126AN N82S153N NMCS50AJ-9 NMCS306N P5101-1 TBP18S030N TBP24S10N TBP	5 5 12 2 2 2 5 4 1 1 1 1 5 3 7 P P P P P P P P P P P P P P P P P P
PBKE36A PBKE36A PBKE47A PBCS3A ZPD2.7V ZENER DK MISC. BZY93C1B SZY93C3B SZY93C SZY9C SZY9C SZY9C SZY9C SZYPSC SZYPS	0.14 0.14 0.88 0.40 0.06 0.06 0.06 0.06 0.06 0.06 0.06	24.00000 24.00000 UM-1 8.000000 8.192000 11.00000 11.100000 11.200000 12.20000 17.73447 18.00000 24.00000 CRYSTALS N HC48/T 1,000000 MINI CYLINDI 0.032768 WATCH 0.032768 CRYSTAL OSC. MODU	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATT 0.1 E98 Series 100P to 255K Price: C0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.15 WATT 0.1 Temp Coeft.39 Frice: C3.85 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.35 WATT 0.1 Temp Coeft.39 Fr.SPH 10R.20P Price: C3.60 E97 Fr.SPH 10R.20P Price: C3.60 E97 Fr.SPH 10R.20P Frice: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 250 Sogn,1K, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 2K, 5H 10DR, 120R, 2K, 5H 10K.20K Price: C3.10 Ear 10DR, 120R, 2K, 5H 10DR, 12DR, 2K, 5H 10DR, 2K, 5H 1DR, 2K, 5H 10DR, 2K, 5H 10DR, 2K, 5H 1DR, 2K,	ON VE D SOR	X2816AD X2816AD X2816AP 25 X2864AP 35 24C01 24C02 24C04 28C04A-20 59C11 93C06 93C46 MISC. MEMOI 6341-1J 6341-1	5 5 12 2 2 2 5 4 1 1 1 1 5 3 3 1 1 2 2 2 5 6 6 3 1 1 3 3 3 3 3 3
PBKE47A PBC947A PBC947	0.14 0.14 0.14 0.88 0.40 0.06 0.06 2.66 2.66 2.266 V.2.68 4.2.66 0.22 0.22 0.23 0.23 0.24 0.09 0.09 0.09 0.09 0.09 0.09 0.09 0.0	24.00000 24.00000 UM-1 8.000000 8.192000 10.00001 11.000001 11.000001 12.28800 15.500000 17.73447 18.00000 27.000000 24.00000 CRYSTALS N HC48/T 1,000000 MINI CYLINDI 0,032768 WATCH 0,032768 CRYSTAL 98.00000 Plaistic Modul	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATT 0.1 E98 Series 100 Pt 0.25 WATT 0.1 E98 Series 100 Pt 0.25 WATT 0.1 Temp Coeff.3p 100 Pt 0.25 WATT 0.	th ON VE D 1% SOR	X2816AD X2816AD X2816AD 25 X2864AP 35 244001 244002 244004 29401 93406 9341-1J 93406 9341-1J 93406 9341-1J 94684 948-45 9	5 5 12 2 2 2 5 5 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
PBKE47A PBC947A PBC947	0.14 0.14 0.18 0.40 0.06 2.66 2.66 2.26 2.26 2.26 2.26 2.2	24.00000 UM-1 8.000000 8.192000 10.00001 11.00000 12.28800 15.00000 15.00000 15.00000 15.000000 15.000000 15.0000000000	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WAT 0.1 STATE 0.25 WATT 0.1 STATE 0.25 WATT 0.1 TEMP COORD. 0.35 WATT 0.1 TEMP COORD. 0.33 WATT 0.1 TEMP COORD. 0.33 WATT 0.1 TEMP COORD. 0.33 WATT 0.1 TEMP COORD. 0.35 WATT 0.1 TEMP CO	th ON VE D SOR Ch SOR Ch MM	X2816AD X2816AD X2816AD 25 X2864AP-35 244001 24002 24004 2401 24006 93044-20 39004-20 39044-2	5 5 12 2 2 2 5 4 4 1 1 1 1 5 3 P P P P 4 2 2 2 5 6 3 3 3 3 4 4 3 3 3 3 3 4 4 3
PBKE-98A PGKE-47A RECSSIA ZPD2.7V ZENER DK MISC. BZY93C7V BZY93C15 BZY93C20 BZX61C9V ZENER DK	0.14 0.14 0.18 0.40 0.06 2.66 2.66 2.26 2.26 2.26 2.26 2.2	24.00000 24.00000 UM-1 8.000000 8.192000 10.00001 11.000001 11.000001 12.28800 15.500000 17.73447 18.00000 27.000000 24.00000 CRYSTALS N HC48/T 1,000000 MINI CYLINDI 0,032768 WATCH 0,032768 CRYSTAL 98.00000 Plaistic Modul	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATTO. E98 Series 100B to 255K Price: £0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATTO. 1 Temp Coeft.39 Price: £3.85 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.33 WATTO. 1 Temp Coeft.39 Price: £3.80 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATTO. 1 Temp Coeft.39 Price: £3.60 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATTO. 1 Temp Coeft.30 HIG.50 VOR. 20 MAIN OF THE COEFT. 20 TEMP C	1% ON VE D 1% PM 50R PM 50R PM 140 200 PM 140 200 PM 140 200 PM 140 PM 1	X2816AD X2816AD X2816AP 25 X2864AP 35 24001 24002 24004 24004 24016 28004A-20 580011 93006 93046 MISC. MEMOR MISC.	5 5 12 2 2 5 5 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
PBKE-98A PBKE-97A PBK	0.14 0.14 0.18 0.88 0.40 0.06 0.06 0.266 0.266 0.266 0.266 0.200 0.040 0	24.00000 24.00000 UM-1 8.000000 8.192000 10.00001 11.000001 11.000001 12.28800 15.00000 15.00000 15.000000 17.73447 18.00000 24.000000 CRYSTALS N MINI CYUINDI 0.032768 WATCH	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.80 2.25 2.80 0.2.50 2.25 5.80 0.88 0.882	PRECISION 0.25 WATT 0.1 E98 Series 100B to 255 K Price: £0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.1 Temp Coeft.3p 10K,30B 10CR,20B 1	1% Ch ON VE D 1% Ch	X2816AD X2816AD X2816AD 25 X2864AP 35 244001 24002 24004 24016 28004A-20 59011 93006 93046 MISC. MEMORI 6341-1J AM2*48-45DC AM273981PC IDT7132LA 1001 MISAM273981PC IDT7132LA 1001 MISAM273998 IDT7132LA 1001 MISAM273998 IDT7132LA 1001 MISAM273998 IDT7132LA 1001 MISAM273998 IDT7132LA 1001 MISAM273999999999999999999999999999999999999	5 5 12 1 2 2 2 5 5 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
PBKE458A PBKE47A RECSSA RPD2-7V ZENER DK MSC. BZY93C7V BZY93C19 BZY93C49 BZY93C20 BZY93C24 BZY93C30 BZY93C40 BZ	0.14 0.14 0.18 0.88 0.40 0.06 0.06 2.66 2.66 2.66 2.66 2.66 0.2.68 0.2.68 0.2.68 0.2.69 0.20 0.00 0.00 0.00 0.00 0.00 0.00 0.0	24.00000 24.00000 UM-1 8.000000 8.192000 11.00000 11.00000 11.00000 11.00000 12.28800 15.00000 15.00000 15.00000 15.00000 15.00000 15.00000 15.00000 15.00000 15.00000 15.000000 15.000000 15.000000 15.000000 15.000000 15.000000 15.000000 15.000000 15.0000000 15.000000 15.000000 15.000000 15.000000 15.000000 15.0000000000	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATT 0.1 E98 Series 100B to 255K Price: £0.94 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.15 WATT 0.1 Temp Coeft.3p Price: £3.85 ear HIGH PRECISI NON-INDUCTI WIRE WOUN 0.33 WATT 0.1 Temp Coeft.3p Price: £3.86 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATT 0.1 Temp Coeft.3p Price: £3.86 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATT 0.1 Temp Coeft.3p Price: £3.86 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATT 0.1 Temp Coeft.3p Temp Coeft.3p Price: £3.86 ear HIGH PRECISI NON-INDUCTI WIRE WOUND 0.33 WATT 0.1 Temp Coeft.3p Te	00 N VE D 1% ON VE D 1	X2816AD X2816AD X2816AD 25 X2864AP 35 244001 24002 24004 24016 28004A-20 59011 93006 93C46 MISC. MEMORI 6341-1J AM2*48-45DC AM2*78-81PC IDT7130LA-1001 IDT7132LA 1001 MIBA*4E MCMA02*7AG3 N82S126AN N82S126AN N82S183N N82S181AN N82S181AN THE PLAY FOR THE	5 5 12 1 1 2 2 7 5 4 4 1 1 1 1 1 1 5 3 7 P P P P 4 2 2 2 5 6 6 3 3 3 3 3 4 4 4 3 3 3 3 3 4 4 4 3 3 3 3 3 4 4 4 3 3 3
PBKE478 PBKE47	0.14 0.14 0.18 0.88 0.88 0.80 0.266 2.66 2.66 2.66 2.66 2.66 0.0.40 0.0	24.00000 UM-1 8.000000 8.192000 10.00001 11.000001 11.000001 12.28800 15.00000 15.00000 15.000000 17.73447 18.00000 24.000000 CRYSTALS N HCAGLT 1.000000 MINI CYUINDI 0.032768 WATCH 0.032768 OBJECT CRYSTAL OBJECT OBJE	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATT 0.1 E98 Series 10.09 to 255 k Price: 60.94 ear 11.09 to 255 k Price: 60.94 ear 11.00 to 11.	1% ON VE D 1% Pm 50R Pm 140 200 1240 2240 2240 2240	X2816AD X2816AD X2816AD 25 X2864AP 35 244001 24002 24004 24016 28004A-20 59011 93006 93046 MISC. MEMOI 6341-1J AM2*48-45DC AM273981PC IDT7130LA-1001 IDT7132LA 1001 MISC. MEMOI 74045 PER MCMA027363 N82S126AN N82S126AN N82S126AN N82S126AN N82S126AN TREPS 101-1 TBP185030N TBP24510N TBP2450N T	5 5 12 1 1 2 2 2 5 5 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
PBKE478 PBKE47	0.14 0.14 0.18 0.88 0.88 0.80 0.266 2.66 2.66 2.266 2.666 2.666 2.666 2.666 2.666 2.666 2.666 2.666 2.666 2.6	24.00000 24.00000 UM-1 8.000000 8.192000 10.00001 11.00000 11.00000 12.29800 15.00000 17.73447 18.00000 24.00000 CRYSTALS N HCAG/T 1.000000 MINI CYLINDI 0.032768 WATCH 0.032768 CRYSTAL OSC, MODU Plastic ph TIL Outp 4 Pins sparade comers of 8pin Freq.= MHz 4, 4,9152, 6 20 Pince 12.98 6 20	2.25 1.14 1.52 1.90 2.25 2.25 2.25 2.25 2.25 2.25 2.25 2.2	PRECISION 0.25 WATT 0.1 E98 Series 100 Pt 0.25 WATT 0.1 Tomp Coeff. 3p 10R, 50R 10R,	1% ch ON VE D 1% 1% 1% 1% 1% 1% 1% 1% 1% 1% 1% 1% 1%	X2816AD X2816AD X2816AD 25 X2864AP 35 24001 24002 24004 4016 28004A-20 580011 93006 9304-6 MISC. MEMOR 6341-1J AM2 48-45DC AM275981PC ID I7130LA-1001 IDT7130LA-1001 IDT713	5 5 12 1 1 2 2 2 5 5 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
PBIKE-36A PBIKE-37A PEC-34A PE	0.14 0.14 0.18 0.88 0.88 0.80 0.266 2.66 2.66 2.266 2.666 2.666 2.666 2.666 2.666 2.666 2.666 2.666 2.666 2.6	24.00000 UM-1 8.000000 8.192000 10.00001 11.000001 11.000001 12.28800 15.00000 15.00000 15.000000 17.73447 18.00000 24.000000 CRYSTALS N HCAGLT 1.000000 MINI CYUINDI 0.032768 WATCH 0.032768 OBJECT CRYSTAL OBJECT OBJE	2.25 1 1 90 2 2 7 5 2 2 2 2 5 2 2 2 2 5 2 2 2 2 5 2 2 2 2 5 2 2 2 2 5 2 2 2 2 5 2 2 2 2 5 2	PRECISION 0.25 WATT 0.1 E98 Series 10.09 to 255 k Price: 60.94 ear 11.00 k 10.15 WATT 0.1 Temp Coeff.39 10R,50R 100R,20 110K,100K Price: 63.85 ear 110K,20K Price: 63.10 ear 110K Price: 63.60 ear 110K Price:	PM P	X2816AD X2816AD X2816AD 25 X286AAP 35 24001 24002 24004 24016 28004A-20 580011 99006 993C46 MISC. MEMOR 6341-1J AM2 48-45DC AM275981PC 1D 17130LA-1001 1D77132LA 1001 MIBA1-4E MCLM0273C3 N82S126AN N82S126AN N82S153N N82S153N N82S153N N8CS504JP 1001 1D7130LA-1001 1D7132LA 1001 MIBA1-4E MCLM027AC3 N82S163N N82S163N N8CS504JP 1001 1D7132LA 1001 MIBA1-4E MCLM027AC3 N82S163N N72S504JP 1001 1D7132LA 1001 MCLM027AC3 N82S163N NMCS504JP 1001 1D7132LA 1001 MCLM027AC3 NRCS504JP 1005CS61AJP 1005CS6AJP 1005CS61AJP 1005CS6AJP	5 5 12 1 1 2 2 5 5 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
PBIKE-05A PBIKE-	0.14 0.18 0.88 0.88 0.80 0.40 0.06 0.266 82.66 82.66 82.66 82.66 0.20 0.00 0.00 0.00 0.00 0.00 0.00	24.00000 24.00000 UM-1 8.000000 8.192000 11.00000 11.00000 11.00000 12.28800 15.00000 17.73447 12.8800 17.73447 1.000000 MINI CYLINDI 0.032768 CRYSTALS N PATCH O 0.032768	2.25 1 90 2 20 2 2.25 2 2.25 2 2.25 2 2.25 2 2.25 2 2.25 2 2.25 4 2.25 2	PRECISION 0.25 WAT 0.1 E98 Series 100 Pt 0.25 WAT 0.1 E98 Series 100 Pt 0.25 WAT 0.1 Temp Coeft.3p 10K,30H 10K,20H 10K,30H 10K,30K 10K	PM P	X2816AD X2816AD X2816AD 25 X2864AP 25 X2864AP 35 244001 24002 24004 24016 28004A-20 58011 93006 93046 MISC. MEMOR MISC.	5 5 12 1 1 2 2 2 5 6 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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0802008 1 1 1 1 1 1 1 1 1	D6284A D6288 D62C284-12	6.42 3.90 6.48 9.60	P8251A 3.9 P8253 2.6 F8255A-5 3.9 P8259 2.6 P8299A 3.2	PBD392303 PP34C108 0 04704 0 04704 0 0MV16BP5 0 0MV18C 0 0MV18CW1	4.35 6.80 3.60 7.98 6.95 7.85	CASSSCE CA741CE CSSS03-KD CX7926B D169CJ DACOBDILCN DACOBDLCN DACOBDLCN DACOBCP	0.18 POA POA POA 4.10 10.67 2.60	LM1496N LM1801N LM1881N LM1889N LM1894N LM218H LM239N LM2901N	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25	MC14495P MC145406P MC1455P MC1455P1 MC1458P MC1488L MC1488P MC1489A MC1489AL	4 82 2.10 0.40 0.60 0.32 2.40 0.38 0.80 2 25	TAA861A TBA120S TBA240B TBA570 TBA820MT TBA920 TC9106BP TCA335A TCA965 TCM1520AP	POA O 60 POA POA POA POA POA POA POA	ZN415E 1 B 2 ZN423 5 S S S S S S S S S S S S S S S S S S	0 BC109B/C 0 18 0 BC140-16 0 48 1 BC149 0 -0 1 BC157 0.34 1 BC158 0 33 1 BC158 0 0.14 1 BC159 0 24 1 BC158 S 0 34 1 BC158 C 0.14 1 BC179 0 24 1 BC179 0 24 1 BC179 0 24	BF961 BF981 BF982 BFG65 BFR91-5GHz BFR91-5GHz BFR91A-6GHz	0 26 24 0.3 540 0 66 24 0.6 540 0 90 28 0.6 60p 0.83 32 0.6 65p 1.79 48 0.6 85p 0.90 64 0.75 260 0.48 0.6 85p 0.90 64 0.75 260 0.20 64 0.9 260p	14p 16p 22p 22p
Magnetian Page Pa	D6284A D6268 D62C284-12 D62C284-8 D62C288 16	6.42 3.90 6.48 9.60 7.85	P8251 A 3 9 P8253 2 6 P8255A-5 3 5 P8259 2 6 P8259A 3.2 P8274 9.5	PBD352203 PP34C168 0 Q4704 00 QMV16BP5 0MV18C 0MV18CN1 0MV18CN1 0MV25C 0MV25C	4.35 6.80 3.60 7.98 6.95 7.85 7.85 8.42 6.90	CA555CE CA741CE CS5503-KD CX7926B D169CJ DAC0800LCN DAC0802LCN DAC08CP DAC08CP DAC08CP DAC08CP	0.18 POA POA 4.10 10.67 2.60 3.64 10.73	LM1496N LM1801N LM1881N LM1889N LM1894N LM218H LM239N LM2901N LM2903N	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25	MC14495P MC145406P MC1455P1 MC1455P1 MC1458P MC1488L MC1488P MC1489A MC1489AL MC1489AN	4 82 2.10 0.40 0.60 0.32 2.40 0.38 0.80 2 25 0.80	TAA861A TBA120S TBA240B TBA570 TBA820MT TBA920 TC9106BP TCA335A TCA965 TCM1520AP 1CM1531P	POA POA POA POA POA POA POA POA POA POA	ZN415E 1 B ZN423 2 21 ZN425E-8 5 9 ZN426E-8 3 6 9 ZN426E-8 6 9 ZN429E 8 2 6 ZN449E 4 7 ZN449E 4 ZN449E	BCIOSBRC 0 18 BCI401 0 0.48 BCI4401 0.08 BCI49 0.40 BCI57 0.34 BCI58 0 34 BCI59 0 24 BCI79 0 24	BF961 BF981 BF982 BFG65 BFR63-2GHz BFR91-5GHz BFR91A-6GHz - HARDWARE& S (Without CPU & DR Expansion	0 26 24 0.1 540 0 66 24 0.6 540 0 90 28 0.6 600 0 80 32 0.6 650 1,79 40 2.6 700 0 48 40 0.6 850 0,99 64 0.75 2600 1,20 64 0.9 2600 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	14p 16p 22p 22p 22p
Decomposition Color Deco	D6284A D6268 D62C284-12 D62C284-8 D62C288 10 D62C288 12	6.42 3.90 6.48 9.60 7.85 10.96	P8251A 3.5 P8253 2.8 P8255A-5 3.5 P8259 2.6 P8259A 3.2 P8274 9.5 P8274-5 3.2 P8282 2.6	10 PP34C168 10 PP34C168 10 O4764 10 O4768 10 OMV16BP5 10 OMV18CN1 10 OMV18CW1 10 OMV25C 10 OMV62AW1	4.35 6.80 3.60 7.98 6.95 7.85 7.85 8.42 6.90 4.20	CA555CE CA741CE CS5503-KD CS5503-KD CX7926B D169CJ DAC0800LCN DAC080CP DAC080CP DAC1008LCN DAC1022LCN	0.18 POA POA 4.10 10.67 2.60 3.64 10.73 20.40	LM1496N LM1861N LM1869N LM1869N LM1894N LM218H LM239N LM2901N LM2903N LM2904N LM2917N-14	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25 6.10	MC14495P MC145406P MC1455P MC1455P1 MC1458P MC1488L MC1488P MC1489A MC1489A MC1489AN MC1489AN MC1489L MC1489P	4 82 2.10 0.40 0.60 0.32 2.40 0.80 2.25 0.80 2.20 0.38	TAA861A TBA120S TBA240B TBA570 TBA820MT TBA820 TGA980 TCA335A TCA965 TCM1520AP 1CM1705AN TCM3105N	POA POA POA POA POA POA POA POA POA POA	ZN415E	BC109BC 0 19	BF961 BF982 BF965 BF965-2GHz BF891-5GHz BFR91A-6GHz - HARDWARE& \$ (Without CPU & DR Expansion ry Slots	24 0.1 540 0.66 28 0.6 600 0.88 32 0.6 600 0.88 32 0.6 600 0.88 48 0.6 700 0.48 48 0.6 550 0.90 64 0.75 2600 1.20 84 0.9 2600 SOFTWARE AM) BoardSize Pi in mm f	14p 16p 22p 22p 22p
PALICIACION 1 9 PALI	D8284A D8288 D82C284-12 D82C284-8 D82C288 10 D82C288 12 O82C288-8 D8748H	6.42 3.90 6.48 9.60 7.85 10.96 1.95 9.36	P8251A 3.5 P8253 2.6 F8255A-5 3.5 P8259 2.6 P8259A 3.5 P8274 9.5 P8279-5 3.2 P8282 2.6 P8286 3.6	PP342108	4.35 6.80 7.98 6.95 7.85 7.85 8.42 6.90 4.20 2.95 5.40	CA555CE CA741CE CS5503-KD CS5503-KD CX7926B D169CJ DAC0800LCN DAC0802LCN DAC08CP DAC08CP DAC108LCN DAC1222LCN DAC1222LCN DAC1222LCN DAC1222LCN DAC1222LCN DAC1222LCN DAC1222LCN DGC11ABK	0.18 POA POA 4.10 10.67 2.60 3.64 10.73 20.40 3.83	LM1496N LM1861N LM1881N LM1889N LM1894N LM2218H LM239N LM2901N LM2903N LM2904N LM2917N-14 LM2917N-18	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25 1.25 6.10 5.80	MC14495P MC145406P MC1455P MC1455P1 MC1458P MC1488L MC1488P MC1489AL MC1489AL MC1489AL MC1489P MC1489P MC1489P	4 82 2.10 0.40 0.60 0.32 2.40 0.38 0.80 2.25 0.80 2.20 0.38 2.20	TAA961A TBA120S TBA240B TBA570 TBA820MT TBA920 TEA990 TC9106BP TCA335A TCA965 TCM1520AP TCM1520AP TCM1705AN TCM3105N TCM3105N	POA POA POA POA POA POA POA POA POA POA	ZN415E 1 B ZN429 2 21 ZN425E-8 5 9 ZN426E-8 5 9 ZN426E-8 6 9 ZN429E 8 2 6 ZN429E 8 4 7 MOTHER BOARD: Processor C Intel S 604865X/DX:DX:DX:DX:DX:DX:DX:DX:DX:DX:DX:DX:DX:D	BC109BC 0 18 BC14801 0.68 BC14801 0.68 BC149 0.40 BC157 0.34 BC157 0.34 BC157 0.34 BC158 0.34 BC158 0.34 BC158 0.44 BC178 0.54 BC188	BF961 BF981 BF982 BF965 BF653-2GHz BF891-5GHz BFR91A-6GHz - HARDWARE& \$ (Without CPU & DR Expansion my Slots	24 0.1 540 0 66 24 0.6 540 0 66 80 0.8 60 0 88 32 0.6 60 0 0.8 60 0.5 70 0 48 48 0.6 550 0 90 64 0.9 280 SOFTWARE HAMP	14p 16p 22p 22p 33 30 irce p
DR331-SHR 2-34 FALLOLLOGINS 3-34 CHICAGO 2-15	D8284A D8268 D82C284-12 D82C284-8 D82C288 16 D82C288 12 O82C288-8 D8748H DM96U1N	6.42 3.90 6.48 9.60 7.85 10.96 11.85 9.36 9.35 2.45	P8251A 9.5 P8253 2.6 P8255A-5 1.5 P8259 2.6 P8259A 3.2 P8274 9.5 P8279-5 3.2 P8282 2.6 P8286 3.6 P82C54 4.7 P82C54 2.7	10	4.35 6.80 7.98 6.95 7.85 7.85 8.42 6.90 4.20 2.95 5.40 3.40	CA555CE CA741CE CA741CE CS5503 - KD CX7926B D169CJ DAC06800LCN BAC0662LCN DAC066P DAC26EP DAC208LCN DAC1222LCN DG201ABK DG211 DG306ACJ	0.18 POA POA 4.10 10.67 2.60 3.64 10.73 20.40 3.83 1.56 3.98	LM1496N LM1861N LM1881N LM1889N LM1899N LM239N LM2901N LM2903N LM2903N LM2917N-14 LM2917N-14 LM2917N-8 LM294OCT15	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25 1.25 6.10 5.80 2.95	MC14495P MC145496P MC1455P1 MC1455P1 MC1458P MC1488L MC1488P MC1488A MC1489AL MC1489AL MC1489B MC1489B MC1489B MC1489B MC1489B MC1489B MC1489B MC1489B MC1489B MC1489B MC1558L	4 82 2.10 0.40 0.60 0.32 2.40 0.38 0.80 2.25 0.80 2.20 0.38 2.20 0.38	TAA861A TAA861A TBA270 TBA270 TBA820MT TBA920 TBA920 TBA920 TC91066P TC4335A TCA965 TCM1520AP TCM1520AP TCM1705AN TCM3105N TCM5089N	POA POA POA POA POA POA POA POA POA POA	ZN415E 1 B ZN429 2 21 ZN425E-8 5 9: ZN426E-8 5 69: ZN429E-8 6 99: ZN429E 8 2 6- ZN449E 4 7: MOTHER BOARD! Processor Intel S 804865X:DX:DX:2 804865X:DX:DX2	BC109BC	BF961	24 0.3 540 066 24 0.6 540 066 28 0.6 560 088 30 650 0.88 40 650 0.48 40 0.6 570 0.48 40 0.5 260 0.90 64 0.75 260 0.70 WARE SAY 250 220 12 SAY 250 12 SAY 250 220 12	14p 16p 22p 22p 22p
DS 12	D6284A D6268 D62C284-12 D62C284-8 D62C288 10 D62C268 12 O62C268-8 D8748H DM96U1N DP8228N	6.42 3.90 6.48 9.60 7.85 10.96 11.85 9.36 9.95 2.45 6.36	P825' A 3 5 P825' A 5 P827' A 5 P827' A 5 P827' A 5 P828' A 5 P828	PBJ35203 PP34C108 O4704 O4704	4.35 6.80 7.98 6.95 7.85 7.85 8.42 6.90 4.20 2.95 5.40 3.40 4.55	CAS55CE CA741CE CA741CE CA741CE CS5503-KD CS5503-KD CX7925B D169CJ DAC080U.CN DAC080U.CN DAC080U.CN DAC080U.CN DAC080U.CN DAC080U.CN DAC0812CN DAC01081U.CN DAC0122U.CV DAC0122U.CV DG2014BK DG2014D DG506ACJ DG506ACJ DG506ACJ	0.18 POA POA 4.10 10.67 2.60 3.64 10.73 20.40 3.83 1.56 3.98 3.25	LM1496N LM1861N LM1861N LM1884N LM1894N LM219H LM2901N LM2903N LM2903N LM2903N LM2917V-14 LM2917V-16 LM2917V-15 LM2940CT15 LM2944CT15 LM2944CT15 LM2944CT15	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25 1.25 6.10 5.80 2.95 2.50 7.60	MC14495P MC1459P MC1455P MC1458P MC1488P MC1488P MC1488A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489B MC1489P MC1558L MC1558L MC1558L MC1558L	4 82 2.10 0.40 0.60 0.32 2.40 0.80 2.25 0.80 2.20 0.38 2.20 0.38 2.20 0.38 2.20 0.38 2.20 0.38 2.20 0.38	TAA861A TAA861A TBA270 TBA220MT TBA920MT TBA990 TC91066P TC4335A TCA965 TCM1520AP TCM1705AN TCM3105N TCM5089N TDA1083 TDA1085	POA POA POA POA POA POA POA POA POA POA	ZN415E	BC109BC 0 19	BF961 BF981 BF982 BF065 BFR63-2GHz BFR91-5GHz BFR91-4-6GHz HARDWARE& (Without CPU & DE Expansion My Slots 7×16(AT),2×22/VE 7×16(AT),2×22/VE 7×16(AT),2×22/VE CO-PRC	24 0.3 540 100	14p 16p 22p 22p 22p 3 3 5
ST-12-12-12-12-12-12-12-12-12-12-12-12-12-	D8284A D8284-12 D82C284-12 D82C284-8 D82C288-10 D82C288-8 D8748H DM96UTN DP8226N DP8238N DP8334BN	6.42 3.90 6.48 9.60 7.85 10.96 11.85 9.36 9.95 2.45 6.36 6.36 2.34	P825' A 3 5 P825' A 3 5 P825' A 3 5 P825' A 3 5 P825' B 2 7 P827' A 3 5 P827' B 2 7 P827' B 2 7 P827' B 2 7 P827' A 4 P82C' B 4 P82C' B 4 P82C' B 4 P81C' B 2 PAI I I I I I I I I I I I I I I I I I I	10	4.35 6.80 3.60 7.98 6.95 7.85 8.42 6.90 4.20 2.95 5.40 4.55 5.76 1.680	CASSSCE CA741CE CA741CE CA741CE CA7926B D169CJ DA606BULCN DA608BULCN DA608BULCN DA60182LCN DA61822LCN DA61822LCN DA61822LCN DG6184BN DG611 DG914BN DG6184CJ DG5688CJ DS14688M:SM	0.18 POA POA 4.10 10 67 2 60 3 64 10 73 20 40 3 83 1.56 3.96 3.25 0.36 4D 1.65	LM1496N LM1801N LM1881N LM1889N LM2918H LM239N LM2901N LM2903N LM2904N LM2917N-14 LM2917N-16 LM2917N-16 LM2940CT15 LM2940CT15 LM2940CT15 LM2940CT15 LM2940CT15 LM2940CT15 LM2940CT15	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25 1.25 6.10 5.90 5.90 2.95 2.50 7.50 0.36	MC14496P MC1459P MC1458P MC1458P MC1458P MC1488L MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1489A MC1588L MC1648P MC1588L MC1648P MC15P MC15P	4 82 2.10 0.40 0.60 0.32 2.40 0.80 2.25 0.80 2.20 0.38 2.20 0.38 2.20 12.40 12.78 1.20	TAA861A TBA12DS TBA24DB TBA570 TBA820MT TBA820 TGA935A TCA96S TCM1520AP TCM351P TCM150AP TCM508PN TCM508PN TCM508PN TDA1086A	POA 0 60 POA POA POA POA POA POA POA 2 40 2 40 2 40 2 96 3 80	ZN415E 1 B ZN429 2 21 ZN425E-8 5 9 ZN426E-8 9 9 ZN428E-8 6 9 ZN428E-8 2 6 ZN448E 7 ZN448E 7 ZN448E 8 2 6 BOSS ZN448E 4 7 ZN448E 8 2 6 BOSS ZNAX ZNAX ZNAX ZNAX ZNAX ZNAX ZNAX ZNAX	BC109BC 0 12 12 13 14 15 15 15 15 15 15 15	BF961 BF981 SF981 SF981 SF982 SF963-2GHz SFF91-5GHz SF	24 0.3 540 0.66 6 9	14p 16p 22p 22p 22p 3 3 5 9 0.00 9,00
SS4466N 3 20 DS446FN 4 80 DS446FN 4	D8284A D8282B4-42 D82C284-42 D82C284-8 D82C288-10 D82C288-8 D8748H DM9601N DP8228N DP8238N DP8304BN DP8304BN DP8304BN	6.42 3.90 6.48 9.60 7.85 10.96 11.85 9.36 9.95 2.45 6.36 6.36 2.34 6.54	P825' A 3 5 P827' A 3	10	4.35 6.80 7.98 6.95 7.85 8.42 6.90 4.20 2.95 5.40 4.55 5.76 1.680	CAS55CE CA741CE CA741CE CA741CE CA7926B D169CI DAC0800LCN DAC0682LCN DAC0682LCN DAC0682LCN DAC0687 DAC108LCN DAC1222LCN DG2014BIK DG211 DG506ACJ DS14C88MSM DS14C88MSM DS14C88MSM	0.18 POA POA 4.10 10 R7 2 60 3 64 10 73 20 40 3 83 1.56 3.98 3.25 0.36 4D 1.65 1.66	LM1496N LM1801N LM1881N LM1889N LM1894N LM2918H LM2901N LM2903N LM2904N LM2917N-14 LM2917N-14 LM2917N-15 LM2940CT15 LM2944CT LM2947CT15 LM2944CT LM294CT15 L	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25 6.10 6.80 2.95 2.50 7.50 0.36 1.39 1.68	MC14496P MC14540P MC1458P MC1458P MC1458P MC1488P MC1488P MC1489A MC1489A MC1489A MC1489A MC1489A MC1499P MC1568 MC1799CP MC1730CP MC1731CP MC1731CP	4 82 2.10 0.40 0.60 0.32 2.40 0.38 0.80 2.25 0.80 2.20 0.38 2.20 0.38 2.20 12.40 1.27 1.20 1.20 1.20 1.20 1.20 1.20 1.20 1.20	TAA861A TBA120S TBA240B TBA570 TBA820MT TBA820MT TBA920 TGA968 TCA335A TCA96S TCM1320AP ICM1331P TCM1705AN TCM5089N TCM5089N TDA1085 TDA1085 TDA1085 TDA1085 TDA11151 TDA1170S	POA 0 60 POA POA POA POA POA POA POA POA 2 40 2 40 2 40 2 90 1 10	ZN415E 1 B ZN425 2 2 ZN425E-8 5 9 ZN425E-8 5 9 ZN425E-8 6 9 ZN425E-8 6 9 ZN429E 8 2 6 ZN429E 8 2 2 6 ZN429E 8 2 ZN429E 8 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	BC109BC	BF961 BF981 BF982 BF982 BF982-2GH2 BF991-5GH2 BF991-5GH	24 0.3 540 0.6 640 0.6 640 0.8 64 0.7 5280 0.8 64 0.7 5280 0.2 0.4 0.5 500 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.7 5280 0.4 0.4 0.7 5280 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.	14p 16p 22p 22p 3 3 5 6 9 0.00 9.00 40 nn 48 00 52 00
SAMPAN S	DB284A DB28B DB2C284-12 DB2C284-8 DB2C288 10 DB2C288 10 DB2C288 8 DB748H OM96UTN DP8228N DP8328N DP8334BN DP8311N DS1221-20	6.42 3.90 6.48 9.60 7.85 10.96 1 85 9.36 9.95 2.45 6.36 6.36 6.36 6.44 4.44	PB25-14 92 92 92 92 92 92 92 92 92 92 92 92 92	10	4.35 6.80 3.60 7.85 7.85 7.85 8.42 6.90 4.20 2.95 5.40 4.55 5.76 8.81 8.81 8.81 8.81 8.81 8.81 8.81 8.8	CAS55CE CA741CE CA741CE CA741CE CA741CE CA741CE CA741CE CA7926B D169CJ DAC080DLCN DAC0802LCN DAC0808CJ DS14C88M.SM DS14C88M.SM DS14C88M.SM DS14C88M.SM DS14C88M.SM AM12D17	0.18 POA POA 4.10 10 67 2 60 3 64 10 73 20 40 3 83 1.56 3.98 3.25 0.36 4D 1.65 1.65	LM1496N LM1801N LM1881N LM1889N LM1894N LM2910N LM2901N LM2901N LM2903N LM2903N LM2903N LM2903N LM2917N-14 LM2917N-15 LM2940CT15 LM2	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25 6.10 5.80 2.95 2.50 7.50 0.36 1.36 1.36 1.36 1.36 1.36 1.36 1.36 1	MC14495P MC1445P1 MC1455P1 MC1455P1 MC1458P1 MC1488P MC1488P MC1488P MC1489AL MC1489AL MC1489AL MC1489AL MC1489AN MC1489AN MC1489P MC1658P MC1668P MC1723CP MC1723CP MC1723CP MC1723CP MC1723CP	4 82 2.10 0.40 0.60 0.32 2.40 0.38 0.80 2.20 0.38 2.20 0.38 2.20 0.38 12.78 1.27 1.27 1.26 1.26 1.26 1.46 1.45 1.45	TAA861A TBA120S TBA240B TBA570 TBA820MT TBA820MT TBA920 TCA335A TCA965 TCM1520AP ICM1520AP ICM1520AP ICM1520AP ICM150BP TCM1705AN TCM50BP TCM1705AN TCM50BP TDA1083 TDA1083 TDA1083 TDA1081 TDA101151 TDA11151 TDA11151	POA 0 60 POA POA POA POA POA POA POA 2 40 2 40 2 40 2 96 3 80 1 10 2 80 4 98	ZN415E 1 B ZN429 2 21 ZN426E-8 5 9 ZN426E-8 5 9 ZN428E-8 6 9 ZN428E-8 6 9 ZN428E-8 6 9 ZN428E-8 7 ZN429E 8 26 MOTHER BOARD: BO486SX:DX:DX2 MICROPROCESS0 802865 165MHz 80386DX:DX:DX2 MICROPROCESS0 803865 165MHz 80386DX:DX:DX3MHz 80486SX:23MHz 80486SX:23MHz	BC109BC O 19	BF961 BF981 BF981 BF981 BF982 BF982 - GM+2 BF992 - G	24 0.3 540 660 6	14p 16p 22p 22p 3 3 5 6 9 0.00 9.00 40 nn 48 00 52 00
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DSSBBIN 496 PCF8570F 7.86 MN38 0.58 HI-574AKD 5 42.50 MM324AN 3.66 MN394 4.90 MN394 4.90 MN394 4.90 MN394 MN	D8294A D820284-12 D820284-8 D820284-8 D820284-8 D820284-16 D820284-8 D820284-8 D820284-8 D8748H DM9601N DP8228N DP83048N DP83048N DP8311N D81221 D81231-20 D81231-20 D81237 D83466N D83467N D8340287N	6.42 3.90 6.48 9.60 7.85 10.96 1 1.85 9.36 9.35 2.45 6.36 6.36 6.36 6.34 6.44 4.44 7.26 3.20 3.20 3.20 4.80 4.80 4.80	PB25-14 32 2 8 PB255A 5 3 8 PB255A 5 3 8 PB255A 5 3 8 PB25B 3 2 PB274 9 3 2 PB274 9 3 2 PB274 9 3 2 PB274 9 3 2 PB275 2 4 1 PB275A 2 4	10	4.35 6.80 7.98 6.95 7.85 8.42 6.90 4.20 2.95 5.40 3.40 4.55 5.76 11 6.80 E159 72 3.60 8.81 8.95 9.00 9.00 9.00 9.00 9.00 9.00 9.00 9	CA555CE CA741CE CA741CE CA741CE CA741CE CA741CE CA741CE CA741CE CA7626B DI-69CI DAC068D DI-69CI DAC068D DAC0682LCN DAC068CP DAC06	0.18 POA POA 4.10 10 f67 2 60 3 64 10 73 20 40 3 83 1.56 3.98 3.25 0.36 6 1.65 1.65 1.44 11.96 1.10 POA 22.20 3.60	LM1496N LM1881N LM1888N LM1894N LM1894N LM291N LM2901N LM2902N LM2902N LM2902N LM2902T1 LM2902T1 LM2902T1 LM2902T1 LM2902T1 LM2902T1 LM2902T1 LM2902T1 LM2901N	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 1.25 6.10 5.80 2.25 0.36 1.39 1.66 2.98 0.64 2.16 8.95 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 2.60 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0	MC14496P MC145406P MC1455P1 MC1458P1 MC1458P1 MC1488P1 MC1488P1 MC1489A1 MC3464A1 MC3464A1 MC3464A1 MC3464A1 MC3464A1 MC3464A1 MC3464A1 MC3464A1 MC3464A1 MC3464A1	4 82 2.10 0.40 0.60 0.32 2.40 0.80 2.20 0.38 2.20 0.33 2.20 1.278 1.20 1.20 0.46 7.54 0.68 0.60 3.20 1.40 6.75	TAA861A TBA120S TBA240B TBA570 TBA820MT TBA820 TBA920 TCA935A TCA965 TCM1520AP ICM1520AP ICM1520AP ICM1520AP ICM1520AP ICM150BP TCM1705AN TCM5089N TCM5089N TCM5089N TCM16087N TCM5089N TDA1085 TDA1085 TDA1181 TDA1181 TDA1181 TDA11815 TDA1515A TDA1515A TDA1515A TDA1515A TDA1515A TDA1515A TDA1578A TDA1578B	POA 0 60 POA POA POA POA POA POA POA POA	ZN415E 1 B	BC109BC O 148 BC149 O 148 BC149 O 148 BC149 O 148 BC157 D 134 BC157 D 134 BC158 O 148 D	BF961 BF982 BF983 BF988 BF988 BF988 BF983 - 2GHz BF891 - 3GHz B	24 0.3 540	14p 16p 22p 22p 22p 22p 0.00 9.00 40 nn 48 00 52 00 52 00 0 A. 0 A. 0 A.
PCF8570P 7.85 6N.09 1.50 10.58081/N 2.50 10.58081/N	D8294A D820284-12 D820284-8 D820284-8 D820284-8 D820284-16 D820286-16 D820286-16 D820286-16 D820286-16 D820286-16 D83048N D83048N D831048N D8311-120 D81231-120 D81232-120 D812322N D834028N D834028N	6.42 3.90 6.48 9.60 7.85 10.96 1 85 9.95 2.45 6.36 6.36 6.36 6.36 6.34 6.34 6.34 6.34	PB25-4 3 2 5 PB255-3 2 6 PB255-4 3 2 6 PB255-4 5 2 6 PB256 3 6 PB256 3 6 PB256 3 6 PB256 4 4 PB256 4 P	10	4.35 6.60 3.60 7.99 6.95 7.85 7.85 8.42 6.90 4.29 5.40 3.40 4.55 5.76 11.80 8.81 8.81 8.81 8.81 8.81 8.81 8.8	CASSCE CA741CE	0.16 POA 4.10 POA 4.10 FOA 4.1	LM1496N LM1881N LM1881N LM1881N LM1894N LM1991N LM2901N LM2901N LM2903N LM2903N LM2903N LM2903N LM2903N LM2917N-14 LM2917N-16 LM2940C0T15 LM2940C0T15 LM2940C1T1 LM301AN LM301N LM311N LM311N-14 LM312H LM317A-T LM317T-SGS LM317T-SGS LM317T-SGS	2.95 7.92 4.80 7.40 4.16 15.75 3.90 1.25 6.10 5.80 2.96 2.50 7.50 0.36 1.39 1.66 2.96 0.36 2.96 0.36 2.96 0.52 0.52 0.52 0.52	MC1-4496P MC1455P1 MC1455P1 MC1458P1 MC1458P1 MC1488L MC1488A MC1488A MC1488A MC1488A MC1488A MC148BA MC148BA MC148BA MC148BA MC168BA MC168BA MC168BP MC163BP MC163BP MC173CP MC373CP	4 82 2:10 0.40 0.60 0.32 2:40 0.80 0.80 2:25 12:40 11:20 0.45 0.60 0.60 0.60 0.60 0.60 0.60 0.60 0.6	TAA861A TBA120S TBA240B TBA570 TBA820MT TBA820MT TBA920 TBA990 TC9106BP TC9335A TCA965 TCM1520AP ICM1520AP ICM1520AP ICM1520AP ICM150AN TCM5087N TCM5089N TDA1085 TDA1085 TDA1085 TDA1151 TDA11705 TDA11515 TDA1515A TDA1578 TDA1578 TDA1578 TDA1578 TDA1578 TDA1578 TDA1578 TDA1578	POA 0 60 POA POA POA POA POA POA POA POA	ZN415E 1B. ZN429 2 21 ZN426E-8 5 96 ZN426E-8 5 96 ZN426E-8 2 6 ZN448E 4 7 ZN448E 5 2 6 ZN48E 5 2 2 ZN4E 5 2 ZN	BC109BC O 148 BC14901 O 48 BC157 D 34 BC157 D 34 BC158 O 34 BC158	BF961 BF981 BF982 BF985 BF985 BF805 BF80	24 0.3 540 10 6 6 6 1	14p 16p 22p 22p 22p 22p 0.00 9.00 40 nn 48 00 52 00 52 00 0 A. 0 A. 0 A.
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F6803P 3.80 R6SC02P 6.95 R6SC0	D8294A D820284-12 D820284-13 D820284-14 D820284-16 D820281-16 D820281-17 D820281-17 D820281-17 D820281-17 D820281-17 D830281-17 D831221 D831281-17 D83406N D83600N	6.42 3.90 6.48 9.60 7.85 9.36 10.96	PB25-14 92 92 92 92 92 92 92 92 92 92 92 92 92	10	4 .55 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .69 6 .50 7 .50	CASSCE CA741CE	0.16 POAR 10 P	LM1496N LM1891N LM1891N LM1891N LM1891N LM1919H LM2391N LM2901N LM2903N LM2903N LM2903N LM2903N LM2903N LM2903N LM2903N LM2917N-14 LM2917N-16 LM2907N LM301AN LM301N LM311N-14 LM311N-14 LM317T-SGS LM319N LM317T-SGS LM319N LM319N LM317T-SGS LM319N LM319N LM317T-SGS LM319N LM319N LM324L LM317T-SGS LM319N LM325N LM324L LM324AN LM325N LM325N LM325N LM325N LM325N LM325N LM326N LM326N LM3367-2.5	2.95 2.48 4.80 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25	MC1-4-95P MC1-4-95P MC1-4-55P1 MC1-4-55P1 MC1-4-55P1 MC1-4-55P1 MC1-4-58P1 MC1-4-58P1 MC1-4-58P1 MC1-4-58P1 MC1-4-55P1 MC1-4-55P1 MC1-6-55P1 MC1-6-55P1 MC1-7-3-6P	4 82 2.10 0.40 0.60 0.32 2.40 0.32 2.40 0.80 0.80 0.80 12.78 0.80 12.70	TAA861A TBA120S TBA120S TBA240B TBA570 TBA820MT TBA920T TBA990 TCS 1058P TCA335A TCA965 TCM1520AP ICM1520AP ICM1520AP ICM150AP ICM150AP TCM1705AN TCM5089N TCM5089N TCM1085A TCM3105N TCM5089N TCM1085A TCM3105N TCM5089N TCM1085A TCM3105N TCM1675A TCM1515A TCM1675A T	POA	ZN415E 1 B. ZN423 2 21 ZN425E-8 5 9 61 ZN426E-8 9 9 61 ZN449E 4 7	BG109BC 0 18	BF961 BF981 BF981 BF981 BF982 BF982 BF982 BF065 BF982 BF991 BF99	24 0.3 546 0.66 24 0.3 546 0.66 24 0.6 540 0.67 28 0.6 500 0.80 40 0.6 500 0.80 40 0.5 700 0.48 64 0.75 280 0.48 64 0.75 280 0.48 64 0.75 280 0.48 64 0.75 280 0.48 64 0.75 280 0.48 64 0.75 280 0.48 64 0.75 280 0.48 0.48	14p 16p 22p 22p 22p 22p 2 2p 2 2p 2 2p 2 2
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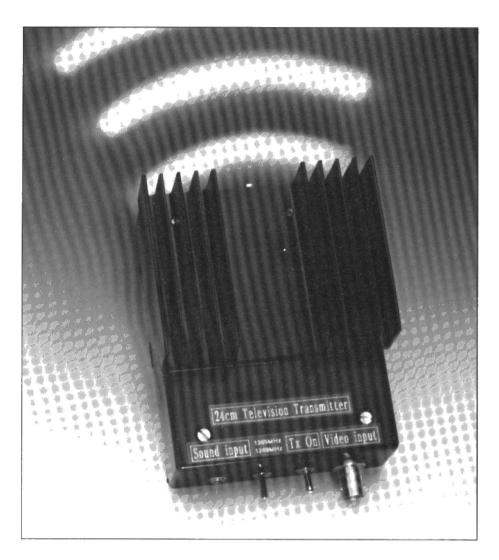
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24 CM FM AMATEUR TELEVISION TRANSMITTER



This article describes a simple 'sure-fire' FM ATV transmitter which uses surface mount technology throughout. It also outlines how a typical amateur TV station operates, and how to receive either signals direct from an amateur, or via a repeater.

By Tim Forrester G4WIM

POR some radio amateurs (and most probably the general public at large), the ability to communicate with other people at a distance has lost much of its mystic, possibly due to the sophisticated communications infrastructure most of the modern world now possesses, and the availability of high performance radio equipment for amateur use. However, for most people, these communications are usually limited to speech or fax, with possible use of slow scan TV still images by li-

censed radio amateurs.

One field where it is still possible for amateurs to experiment and build their own equipment is that of fast scan television. Few visitors (licensed or not) to a ham radio shack equipped with television equipment fail to be enthralled by the ability to talk and see the person 'at the other end', even if the other station is only a couple of miles away.

Building up an ATV station does not have to be time consuming or expen-

sive, especially as many households already have a camcorder and a satellite TV receiver. They only require a suitable transmitter and aerial to transmit pictures (an amateur radio licence is also obviously necessary!).

A brief background to amateur TV

Radio amateurs have been experimenting with fast scan TV (normal broadcast field and line rates) for many years, but due to licence and other technical restrictions experiments were usually conducted on the 435 MHz (70 cm) band. The bandwidth available to amateurs on 70 cm is restricted, which means it is only possible to use amplitude modulation (AM) with colour transmissions just being possible with careful filtering of the transmitter output. The use of ATV repeaters in this band is certainly not possible!

However, many radio amateurs use 435 MHz AM vestigial sideband TV successfully for long distance one-to-one contacts, often over hundreds of miles when propagation conditions are favourable.

Recently, with the advent of cheap satellite TV receivers which cover the 1.3-GHz amateur band, the possibility of high quality FM TV (colour and sound) has been made possible for many amateurs who previously would have thought that operation at such a high frequency would present too many problems. But perhaps more importantly, the 1.3-GHz band with its greater bandwidth has meant that ATV repeaters are able to be licensed.

For those of you who would like more information about amateur TV generally, I suggest joining the British Amateur Television Club (BATC), they can be contacted at 5 Ware Orchard, Barby, Near Rugby, Warwickshire CV23 8UF. VIIF Communications at the same address as the BATC also frequently publishes ATV related projects.

Choosing a suitable satellite TV tuner

Probably the best way to start discovering what amateur TV (ATV) is all about is to acquire a suitable receiver. The problem is with so many different models and standards, what sort to choose. I would not necessarily recom-

mend dashing off to Dixons and buying the latest hi-tech offering from Japan!

As many satellite viewers regularly upgrade their equipment, it is best to try and search out a second-hand unit which can be modified if necessary. This is the approach most 24-cm ATV beginners tend to take. Often the small ads in the local paper contain suitable tuners which can be modified. At the moment there is a glut of BSB units, some of them brand new, going for under £20. The problem is that they were designed for D2MAC which uses slightly different pre-emphasis and digital sound, so unless you are prepared to spend some time and money modifying them for PAL and building a sound demodulator, I suggest looking for more basic equipment.

The following is a list of tuners which are known to work well with little or no modification. There are many more types which could work equally well, but unfortunately it is beyond the scope of this article to give a complete list. A chat with your local ATV technical expert will probably put you on the right track.

Make	Model
Nokia	SAT1600
Nokia	SAT1700
PACE	PRD800
PACE	PRD900
BUSH	SM1000

Amateur TV repeaters

The main advantage of a repeater is that everyone can see (and hear) everyone else. even if they are using low power from a poor location with nobody else within 'simplex' (one-way) range. Obviously, the better sited (higher) the repeater, the greater the coverage and number of viewers it is likely to have.

The ATV repeater GB3MV, for instance, covers the town of Northampton and surrounding villages. Several stations use powers of less than 50 mW at distances of more than 12 miles away to access the repeater with noise-free pictures. The repeater itself runs 10 watts output into an omni-directional 'Alford' slot aerial which is also used on receive (simultaneously!) by means of careful filtering.

Stations running such low power are able to access the repeater by virtue of its very low-noise (sensitive) receiver and optimized FM demodula-

There are now a number of active repeaters throughout the country, with more becoming operative every year. Typically, they are left on air 24 hours a day transmitting test cards

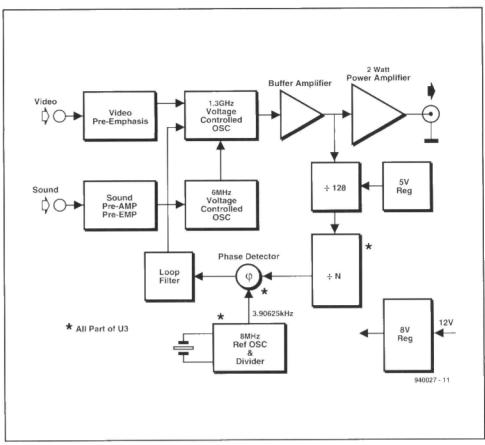


Fig. 1. Block schematic of the ATV transmitter.

			Net
Callsign	Channel	Location	Notes
GB3CT	RT2	Crawley	
GB3ET	RTS	Emley Moor	
GB3GT	RT2	Glasgow	
GB3GV	RT2	Leicester	
GB3HV	RT3	High Wycombe	
GB3LO	RT2R	Lowestoft	
GB3MV	RT2R	Northampton	
GB3NV	RT2	Nottingham	
GB3PV	RT2	Cambridge	
GB3RT	RT2	Coventry	
GB3TG	RT103	Milton Keynes	
GB3TN	RT2R	Fakenham	
GB3TT	RT2R	Chesterfield	
GB3TV	RT2	Dunstable	
GB3UD	RT2	Stoke on Trent	
GB3UT	RT1	Bath	Non-operational
GB3VI	RT?	Hastings	Non-operational pending change to FM
GB3VR	RT2	Worthing	10 1 111
GB3XT	RT103	Burton on Trent	
GB3ZZ	RT2	Bristol	
ATV repea	ater channel fro	equencies	
Channel	Input freq.	Output freq.	Mode
RT1	1276 MHz	1311.5 MHz	AM
RT2	1249 MHz	1318.5 MHz	FM
RT2R	1249 MHz	1316 MHz	FM
RT3	1248 MHz	1308 MHz	FM
RT101	10200 MHz	10040 MHz	FM
RT102	10255 MHz	10150 MHz	FM
RT103	10250 MHz	10150 MHz	FM

Table 1. Main data on ATV repeaters in the UK.

when not actually being used as a repeater. The test card in beacon mode serves as a useful signal for people wishing to aim their antennas and align receivers. The test card 'pages' contain the usual colour bars and often text carrying local amateur radio news and technical details about the repeater. Every few minutes the repeaters also identify themselves in CW (morse code) on the audio channel.

The presence of a video signal on the repeaters input will result in the repeater becoming active and relaying the signal being received. In most cases, there is no need for tone access as with voice repeaters.

Table 1 gives a list of 1.3 GHz (24 cm) repeaters in the UK along with their channel numbers (apologies if any of the data below is out of date by the time this article is published).

Recently, to increase the coverage area of ATV repeaters, plans are being formulated to link one repeater to another using point-to-point microwave links. Indeed, GB3TG is already linked to GB3TV via 10 GHz (3 cm), and there are plans to link GB3MV to GB3TV via GB3TG on possibly 2.3 GHz (13 cm).

Design of a 24-cm ATV transmitter

Due to the availability of satellite receivers, getting going on receive is usually the first step towards operating on TV and normally presents few problems. Having successfully received some amateur signals, viewers more often than not want to start transmitting as well! The problem is how to construct an effective transmitter, given the inherent problems of 1.3GHz construction.

One of the major hurdles with any

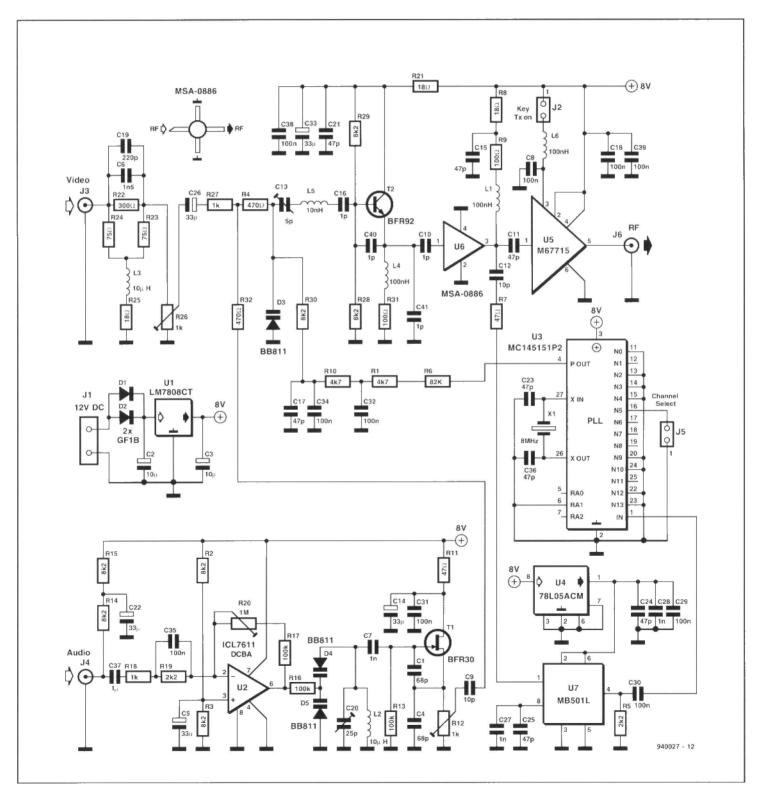


Fig. 2. Circuit diagram of the 24-cm ATV FM amateur television (ATV) transmitter.

1.3-GHz design is consistency, i.e., ensuring that any copy of the design is built exactly the same, even down to component lead lengths, height above the PCB, etc. Other problems are the frequency stability and power output — both must be adequate to ensure a noise free picture into the repeater.

Dealing with the problem of components first, this design is totally surface mount. That means all the components are soldered directly to the board with pre-set lead lengths and at a pre-determined height above the PCB.

This technique ensures a high degree of repeatability, and, as a bonus, a compact, easily portable unit for 'outside broadcast' use!

Obviously, a free-running oscillator at 1.3 GHz is going to drift, but as the bandwidth is typically 15 MHz, that is not too much of a problem. This transmitter, though, is a fairly powerful compact design, and the heat dissipated by other parts of the circuit could lead to unacceptable amounts of frequency drift. Therefore, a simple phase locked loop (PLL) is included to maintain frequency stability — more on the design of the loop later. If operators do not mind the occasional re-tune of the transmitter frequency, it is possible to leave out the PLL circuits and install a potentiometer to set the operating frequency. This approach makes for a unit costing approximately £30 less than for the complete device. Of course, the PLL circuit could always be added at a later date.

RF power gain at 1.3 GHz can be difficult to achieve (and expensive) using individual components. Fortunately these days it is possible to buy RF power amplifiers which come in the form of modules offering guaranteed performance. Their cost is considerably less than buying the individual parts, and there are no alignment problems.

The inclusion of the sound circuitry is very simple, based upon well proven techniques, and does not merit much description. It, too, uses surface mount parts for the sake of consistency and ease of mounting the PCB. Other designs have been published which use more complex audio circuits and sub-carrier oscillators, but it has been found that this simple circuit is perfectly adequate for working simplex and into the repeater. GB3MV actually uses a more complex arrangement to peak-limit the deviation and maintain the sub-carrier frequency to tighter limits

As mentioned above, 70-cm ATV has traditionally used amplitude modulation (AM) which means that all the modulation stages and subsequent amplifiers had to be linear if picture

distortion was to be avoided.

On 24 cm, frequency modulation (FM) is almost universally used. FM offers several advantages over AM for TV work, and few disadvantages. Perhaps the major advantage is that RF amplifiers can operate in class C, i.e., a nonlinear, but high efficiency mode. Also, a properly designed FM TV receiver can exhibit a much better picture quality for a lower RF signal to noise ratio at the receiver input. These two reasons alone explain why FM is used for satellite TV broadcasting, and why amateurs have adopted similar techniques and standards.

Broadly speaking, any FM TV transmitter comprises the same basic stages, as follows:

- RF oscillator, either on frequency or multiplied to final frequency;
- Pre-emphasized FM modulator, usually associated with (1) above;
- (3) Frequency maintaining phase locked loop;
- (4) Sound amplifier and sub-carrier oscillator;
- (5) RF power amplifiers.

As can be seen from the block diagram in **Fig. 1**, the present design follows the basic principles outlined above.

The circuit is given in detail in Fig. 2. The RF oscillator is formed by T_2 running directly at 1.3 GHz. Varicap diode D_3 is used to modulate the oscillator's frequency with both baseband video and the 6-MHz sound sub-carrier. In conjunction with the PLL circuits it also maintains the desired mean frequency.

As FM noise rises with frequency, a better overall system signal to noise ratio can be achieved by boosting (preemphasising) the high frequency video signal, and then using de-emphasis at the receiver to restore the desired flat frequency response — the same principle as used on terrestrial FM radio.

In this design, the components between J_3 and R_{26} perform pre-emphasis to CCIR 405, a widely used broadcast standard. Preset R_{26} sets the total video deviation.

Integrated circuits U_6 and U_5 amplify the low-level signal from T_2 up to about 2 watts output.

The transmitter RF output is turned on by applying bias to U_5 via a switch on J_2 . The PLL is left running all the time power is applied to the unit.

Circuit U_2 is a the sound pre-amplifier and pre-emphasis circuit, with T_1 being a frequency-modulated 6-MHz oscillator. The exact frequency and level of the sound sub-carrier is set by C_{20} and R_{12} respectively.

The PLL used in this design is very basic and uses only two ICs, U_3 and U_7 . There is no loop filter opamp.

Instead, the output of U_3 is used directly to drive the loop filter whose output (via R_{30}) controls the mean voltage on D_3 , and thus the oscillator frequency. R_1 and R_6 are in series purely to make the PCB layout easier!

 $\rm U_7$ is used as a fixed divide-by-128 prescaler to bring the output of $\rm T_2$ down to within range of $\rm U_3$. The reference frequency of $\rm U_3$ for use with its internal phase detector is 8 MHz divided by 2048, giving a reference of 3.90625 kHz. This results in a channel step of 500 kHz at 1.3 GHz when it is effectively multiplied by 128 with $\rm U_7$.

For good quality pictures, the overall frequency response of a TV transmitter ideally would be from DC to approximately 5.5 MHz. Usually, the high frequencies are not too much of a problem, provided care is taken with the design. However, when using a PLL which tries to maintain the nominal carrier frequency, if the PLL bandwidth is too great, it can effectively strip off any low frequency components. Therefore, to ensure the PLL cannot attenuate or distort the low frequency frame sync pulses, it must have a loop bandwidth of less than 50 Hz. The design presented here has a loop bandwidth of about 30 Hz, easily low enough to ensure adequate low frequency response.

A side effect of using a low loop bandwidth with a basic design like this is the PLL lock time. Typically, the PLL could take several hundreds of milliseconds to acquire lock from switch on. That is why in this design the PLL is kept 'alive' all the time, and the transmitter turned on by applying bias to the PA. This technique offers the benefit of having a low-level signal present for picture alignment purposes before actually going 'on-air'.

The low loop band bandwidth of 30 Hz also makes it very easy to attenuate any traces of the 3.90625 kHz reference frequency, which may otherwise leak through into the signal path, and modulate the transmission.

By varying the divide ratio in $\rm U_3$, it is possible to program any other frequency in the band to a resolution of 500 kHz. With a jumper (or switch) across $\rm J_5$, the transmitter will operate on 1249 MHz, the most popular repeater input frequency. Due to spreads in $\rm X_1$, $\rm C_{23}$ and $\rm C_{36}$, the reference oscillator may not be exactly on 8 MHz, and may result in a slight frequency offset of up to 100 kHz — not a problem with a 15-MHz receiver bandwidth! If desired, $\rm C_{23}$ could be trimmed to ensure operation on exactly 1249MHz.

Leaving J_5 open-circuit results in the transmitter operating on 1265 MHz for simplex operation. All the 'N' programming inputs to U_3 have internal pull up resistors, so its quite

COMPONENTS LIST

Resistors:

All resistors and presets SMT 0.25W. Resistors size 1206.

 $R1;R10 = 4k\Omega 7$

 $R2;R3;R14;R15;R28;R29;R30 = 8k\Omega 2$

 $R4;R32 = 470\Omega$

 $R5:R19 = 2k\Omega 2$

 $R6 = 82k\Omega$

 $R7;R11 = 47\Omega$

 $R8:R21:R25 = 18\Omega$

 $R9;R31 = 100\Omega$

R12;R26 = $1k\Omega$ preset (Bourns 3304W)

 $R13;R16;R17 = 100k\Omega$

 $R18;R27 = 1k\Omega$

 $R20 = 1M\Omega$ preset (Bourns 3304W)

 $R22 = 300\Omega$

 $R23;R24 = 75\Omega$

Capacitors:

All capacitors SMT series ATC100A, size 0805 unless otherwise noted

C1;C4 = 68pF

C2;C3 = 10µF electrolytic

C5;C14;C22;C26;C33; = 33µF tantalum

C6 = 1nF5

C7:C27:C28 = 1nF

C8;C18;C29-C32;C34;C35;C38;C39 =

100nF ceramic, size 1206

C9;C12 = 10pF

C10;C16;C40;C41 = 1pF

C11;C15;C17;C21;C23;C24;C25;C36 =

47pF

C13 = 5pF trimmer (Stettner)

C19 = 220pF

C20 = 25pF trimmer (Stettner)

 $C37 = 1\mu F$ ceramic, size 1206

Semiconductors:

D1;D2 = GF1B

D3:D4:D5 = BB811

T1 = BFR30

T2 = BFR92

U1 = LM7808CT

U2 = ICL7611DCBA

U3 = MC145151P2 (Motorola)

U4 = 78L05ACM

U5 = M67715 (Mitsubishi)

U6 = MSA-0886 (Avantek)

U7 = MB501L flatpack (Fujitsu)

Inductors:

All inductors SMT, Siemens SMD02 L1;L4;L6 = 0µH1

 $L2;L3 = 10\mu H$

L5 = 10nH

Miscellaneous:

J1-J6 = 2-pin header

X1 = 8MHz crystal

Printed circuit board (see p.22).

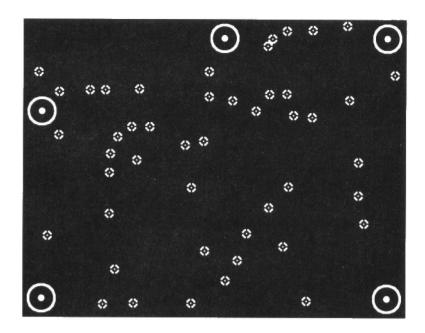
Diecast case, Hammond 1590BB.

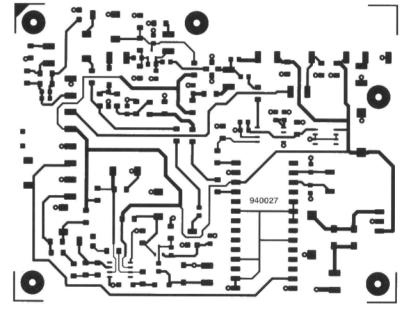
Heatsink 7.5x9.7x2.5cm. (SK04 75mm) BNC socket.

2 miniature on/off switches.

Jack (3.5mm) and DC supply socket.

SMC RF socket.





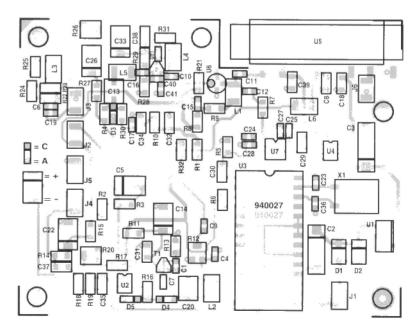


Fig. 3. Artwork for the double-sided fibreglass printed circuit board designed for the transmitter.

in order to leave J₅ open-circuit.

Construction

Virtually all the parts used in this design are readily available surface mount types, however there are a few parts which are normally leaded. X1, U_1 and U_3 require converting to surface mount, easily achieved by forming the leads to fit the pads on the PCB.

Generally, the use of surface mount parts throughout makes installing the PCB into a case very easy with no need for special spacers etc. Additionally, by fastening the PCB directly down to the case, a good earth is ensured between the PCB ground plane, RF power amplifier module and the case. This, in turn, leads to a more reproducible design with less chance of RF instability due to circulating earth currents.

The PCB is designed to fit into a standard diecast box approximately $120 \times 95 \times 3.5$ cm $(4.75 \times 3.75 \times 1.4$ inch). If continuous operation is envisaged, an additional heatsink is recommended. **Figure 4** shows how the PCB and controls are arranged.

In certain critical areas operating at 1.3 GHz. ATC capacitors are used. I would not recommend using any other manufacturer, otherwise the circuits may not operate as intended.

Building the unit up is very easy, providing a small-tipped iron, a pair of tweezers and fine gauge (32SWG or similar) solder are used. It is recommended that all passive parts are loaded first, followed by the semiconductors, leave fitting the RF power amplifier till last when the unit has been tested and is ready to be finally installed in its case.

Ensure that when loading polarized components (especially diodes and capacitors) they are fitted the correct way around. An obvious statement, but when using surface mount components it is sometimes difficult to identify which end is which. **Figure 3** shows the location of all parts on the PCB, and identifies the polarity of diodes and electrolytic capacitors by means of a bar. So, with reference to the circuit diagram in **Fig. 2** it is possible to determine the correct orientation.

While building the unit, take care to inspect each joint as its made. Then, if possible, before applying power, wash the PCB in a suitable solvent and then check all the joints again. Care in construction will save many hours of faultfinding and possibly damaged components.

Testing

It is assumed that constructors have no suitable 1.3-GHz test equipment,

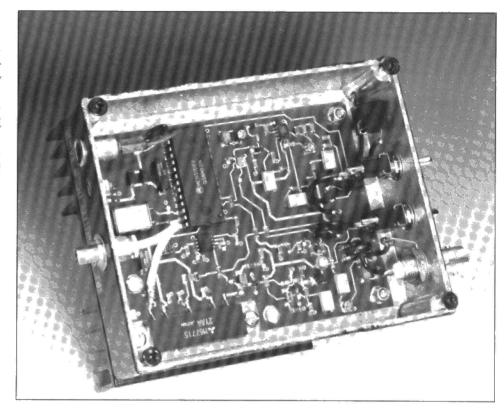


Fig. 4. Internal view of the author's prototype. Note how the PA module is bolted to the bottom of the enclosure and the heatsink on the back.

but do have a satellite receiver, a source of composite video and a DVM or high-impedance multimeter.

The first step is to ensure that the PLL is operating and holding the frequency on 1249 MHz. Make sure that J_5 is in place, then apply power. Monitor the voltage at the junction of R_{10} and R_{30} . Next, adjust C_{13} until the voltage reading is approximately 4 V. Remove the trimming tool after each adjustment as stray capacitance from the trimming tool will often affect the oscillator's free-running frequency and hence the required control voltage from the PLL.

Remove the link, so programming the PLL for 1265 MHz, and note that the voltage increases to something less than 7.5 V. If all is well, replace the link and tune the satellite receiver to 1249 MHz. A blank raster or similar should be on the screen.

A small aerial (even a piece of wire would suffice) connected to the solder spot for pin 1 of $\rm U_5$ may be necessary to ensure an adequate signal for the satellite TV tuner, but take care not to overload the receiver.

Set both R_{12} and R_{26} fully counter-clockwise. Next, apply a video signal to J_3 . Gradually turn R_{26} clockwise until a picture is seen with a good balance between contrast and grey scale. Ideally, use a pattern generator as a source of video.

Connect an electret microphone to

 J_4 , and set R_{20} mid-way. Make sure that the satellite tuner sound channel is set for 6 MHz. While watching the picture, turn R_{12} until a slight patterning can be seen, then reduce it until it just becomes invisible. Adjust C_{20} for maximum quieting on the sound channel combined with best audio quality.

Following the above procedure should be sufficient to get the unit operating, but some of the settings may require fine adjustment 'on air' when working a more distant station.

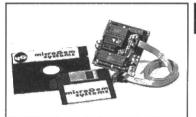
Having completed the preliminary low power alignment, install the PCB into its case and solder the RF power amplifier in place, along with the RF output cable and other connections. With reference to the photograph in **Fig. 4**, note the use of copper tape under the PA module and PCB to aid RF earthing.

If an RF output power meter or dummy load is available, connect it to the RF output, and with an ammeter in series with the main supply, turn the unit on and key the transmitter on by linking J_2 . The total current drawn should be just under 1 A, and the RF output power approximately 2 W. Standby current should be about 75 mA.

Connecting the unit to an aerial is all that is required to go 'on air'.

I would recommend the use of a G3JVL quad loop yagi aerial, as this particular design offers excellent gain

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> versation with the person on the receiving end! It seems to be an unwritten rule that this is permissible, providing the license holder is present to monitor proceedings. On this basis

> For those stations watching but not able to transmit, talkback usually takes place on 144.750 MHz or 144.725 MHz, so offering full duplex operation of sound.

> ATV can get the whole family involved

NOTE If all of the above has got you fired-up and keen to disconnect the satellite tuner from the LNB and fit a 23cm aerial in its place, a word of caution. The d.c. power for LNB units is sent up the coax. That is OK if you are planning to fit a mast head preamp, and power it in the same manner as the LNB, but if your tuner has sufficient sensitivity or you live close to the repeater and decide you don't need a pre-amp, then be careful to either disconnect the DC feed inside the tuner, or use an aerial which is a DC open circuit.

Otherwise you stand a chance of shorting out the LNB power feed. If it is not current-limited, you could do some damage. Some tuners however have an LNB fuse, in which case it is just a matter of removing the fuse when using an external aerial which is a

short to d.c.

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and, perhaps more importantly, adequate bandwidth to cover both repeater input and output frequencies. The designer of this antenna, Mike Walters G3JVL, can be contacted at 26 Fernhurst Close, Hayling Island, Hants, PO11 ODT.

Often two aerials are used, one for transmit and one for receive. If they are placed sufficiently far apart it is usually possible to run 'look through' on a repeater without any additional filtering.

ATV operation

Ideally all amateurs aiming to use ATV should try to run 'look through' when operating through a repeater. Running 'look through' offers several advantages, probably the most important being able align and adjust your signal through the repeater for best effect. Secondly, if any one else wishes to use the repeater, he or she can usually be seen to cause patterning. Etiquette normally decrees that the present user drop out and let the other station operate!

One of the unusual aspects of ATV is that when a station is on air, other people (usually unlicensed) often get in on the act and find themselves being televised and sometimes having a con-

Conclusion

In an article such as this it is impossible to cover and explain all the various aspects of ATV operation, but it is hoped that a little light has been shed on the subject for those readers who have never heard of amateur TV.

Television is a very technical field and much more demanding in terms of equipment performance and operation than, say, voice communication. However, because of these problems. the rewards for success are that much greater and well worth the effort.

Well that's about it, hope to SEE you soon!

A high-quality printed circuit board for the 24cm ATV transmitter is available from the author. For price and ordering information, write to T. Forrester, 24 Corran Close, Dallington, Northampton NN5 7AL. The author also supplies some of special components used in this project. Two suggested sources for the M67715 are Electronic Microwave Components (EMC) Ltd. (0376) 561116, and Misubishi Semiconductor Division (0707) 276100.

MINI PREAMPLIFIER

Design by T. Giesberts

The two major properties of the design described are simplicity and quality. Simplicity is achieved by omitting such superfluous facilities as tone control, mono-stereo selection, rumble filters, noise filters, and so on. Such measures also improve the quality, which may be further enhanced by the use of the best available components

The changes that have taken place in $oldsymbol{1}$ the audio world over the past decade are reflected in design philosophy. In the past there were two clear camps in audio engineering: one that advocated full control of frequency, the use of various filters, and so on, and the other which wanted the minimum of controls. Nowadays, what is the use of a 33/78 input and a rumble filter in the absence of a record player? Why have a noise filter when available signal sources do not produce noise? And what is the use of a mono-stereo selector? Moreover, the quality of current signal sources and the recording quality of compact discs surely make tone control,

and equalizers superfluous?

When all these facilities are omitted, what is left? Only the basic functions: input selection, volume control, balance control, and perhaps a separate selector for record out. These functions require relatively few components and that is an aspect that audio purists have always seen as a great plus point. After all, what is not there can not cause noise or distortion.

The design

Figure 1 shows that the omissions discussed earlier result in a fairly simple cir-

cuit. The input signals enter via phono sockets K_1 – K_{12} . Each of the inputs is individually terminated by R_1 – R_{12} . Switch S_1 selects the record out signal, which is applied to output sockets K_{13} and K_{14} via R_{13} and R_{14} . Switch S_2 functions as the standard input selector.

The signals at poles ${\bf A}$ and ${\bf B}$ of S_2 (lefthand and right-hand channels respectively) are applied to a further terminating resistor, R_{15} (R_{16}). The overall terminating impedance of the selected input has the standard value of 47 k Ω . The signals are then applied to a buffer stage, IC $_1$ and IC $_2$, which is arranged as a unity gain amplifier. Since the NE5534 is not inherently unity gain stable, a compensation capacitor, C $_1$ (C $_2$), is connected between pins 5 and 8.

The output of the buffer is applied to a voltage amplifier, IC $_3$ (IC $_4$) via balance control P $_1$ and volume control P $_2$. The amplification of IC $_3$ (IC $_4$) is set to ×5.5 with the aid of R $_{22}$ -R $_{23}$ (R $_{25}$ -R $_{26}$). This ensures that in spite of the losses in the balance control a nominal output level of 1 V is obtained with an input of 250 mV.

The outputs of IC_3 and IC_4 are applied to output sockets K_{15} and K_{16} respectively via contacts of relay Re_1 . Delay stage T_1 arranges for the relay to be energized a few seconds after the supply has been switched on. This ensures that any switch-

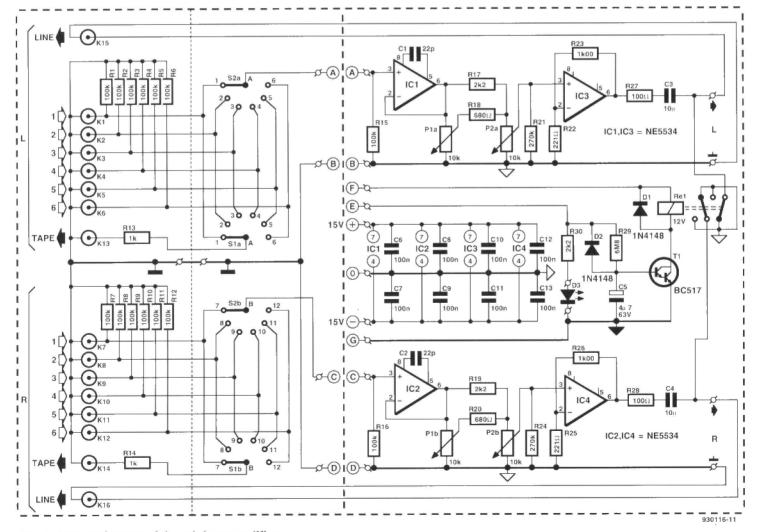


Fig. 1. Circuit diagram of the mini preamplifier.

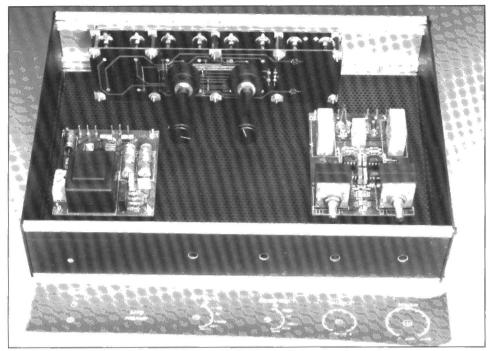


Fig. 2. General view of the (nearly completed) mini preamplifier.

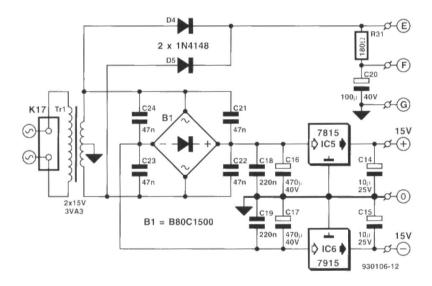


Fig. 3. Circuit diagram of the power supply for the mini preamplifier.

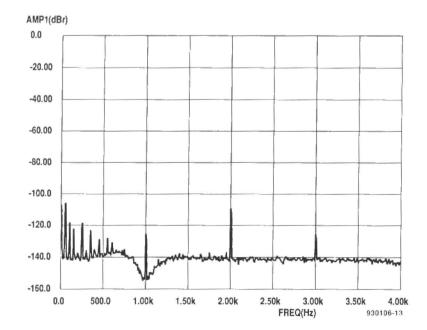


Fig. 4. The THD characteristic leaves little to be desired.

on noise is kept away from the outputs. On-off indication is given by D₃-R₃₀.

The design of the power supply follows the same philosophy as the amplifier: no complicated circuits where simple ones will do. Circuits IC_5 and IC_6 are voltage regulators. The delay stage derives its own supply directly from the secondary of the mains transform er via D_4 , D_5 , R_{31} , C_{20} .

Enhancement measures

Quality starts with the constituent components. For example, there are many types of phono input socket available, but for best results only gold-plated ones will do. Good-quality rotary switches are also a must, but these can prove difficult to obtain. The type of potentiometer used for the balance and volume controls has a very real influence on the quality of the amplifier. Again, for best results, use a top quality type, such as Alps. Capacitors C₃ and C₄ should preferably be MKT types, but MKP ones will do as well. Note, however, that the printed circuit board (see Fig. 5) can cope with less expensive types of passive components as well.

There is a wide choice of integrated circuits as shown in the parts list. This does not mean that the NE5534 used in the prototype is not a satisfactory choice, but there are other, more expensive, types that may meet an individual need better. It should, however, be borne in mind that a more expensive device does not always provide better aural quality.

Of course, there are different yardsticks for the buffer and the amplifier. For the buffer, low noise and a high input impedance are prime requirements, whereas for the amplifier a good gain-bandwidth product and a low output impedance are important. The slew rate reflects much about the quality of an opamp, but its importance in top-quality audio equipment must not be exaggerated: other parameters may be just as important.

Since few people will be able to try out all the operational amplifiers in the parts list, the author's recommendations are the SSM2131 for IC1 and IC2 (the OPA627 is also excellent, but perhaps rather expensive for this application) and the OPA637 for IC3 and IC4. In the latter case, the LT1028 and OP37 are good second choices. Bear in mind that all types which are not unity gain stable require special compensation when they are used as buffers. This compensation varies from one type to another and is not always wholly satisfactory. It is, therefore, best if the recommended type is not used to choose another that is unity gain stable. Compensating capacitors C1 and C2 should be omitted when unity gain stable types are used.

Construction

Before construction is started, cut or saw the printed circuit board in **Fig. 5** into four along the lines indicated. Populating the four constituent boards should prove straightforward.

Interconnect E, F, G '-', 0 and '+' on the supply board and the amplifier board with appropriate lengths of flexible circuit wire.

Sandwich the other two boards together with the aid of spacers as shown in Fig. 7 and interconnect them with short lengths of bare wire. The interconnections between the boards near K_{13} and K_{14} is via R_{13} and $R_{14}.$ Note that resistors $R_1\text{--}R_{12}$ are soldered directly to the terminals of the phono sockets. When the sandwich

has been completed, connect A, B, and C, D to the amplifier board via two short lengths of screened cable.

Connect the outputs of the amplifier board to output sockets K_{15} and K_{16} via two lengths of screened cable.

The boards can then be built into a suitable enclosure. It is the intention that the sandwiched boards are mounted on the inside rear panel and that the spindles of the rotary switches are extended to the front panel—see **Fig. 8**. A suggested front panel suitable for a number of enclosures is shown in **Fig. 6**. It should not

prove difficult to adapt this to a particular enclosure.

Some parameters

- The input sensitivity is 250 mV into $47 \text{ k}\Omega$ for an output of 1 V into 100Ω .
- Channel separation is 82 dB at 1 kHz.
- Noise suppression and total harmonic distortion (THD) are shown in **Fig. 4**.

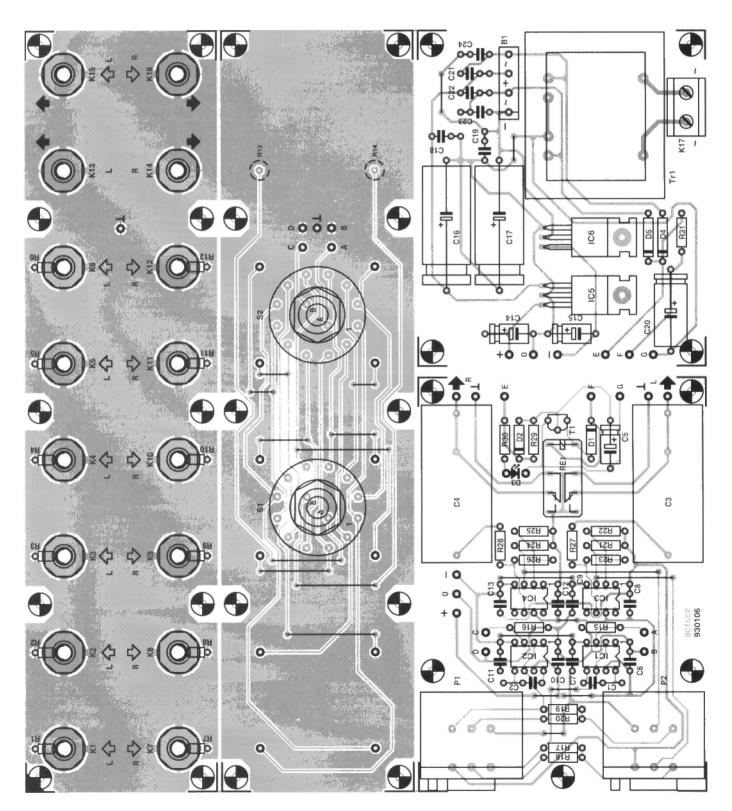


Fig. 5 (a). Printed circuit board (component layout) for the mini preamplifier.

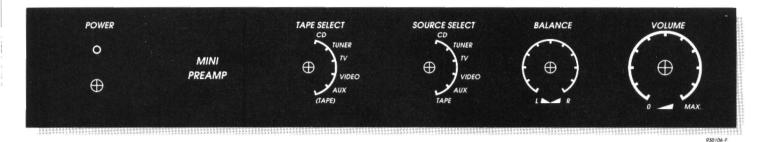


Fig. 6. Suggested front panel layout (not to scale). There is no ready-made foil available.

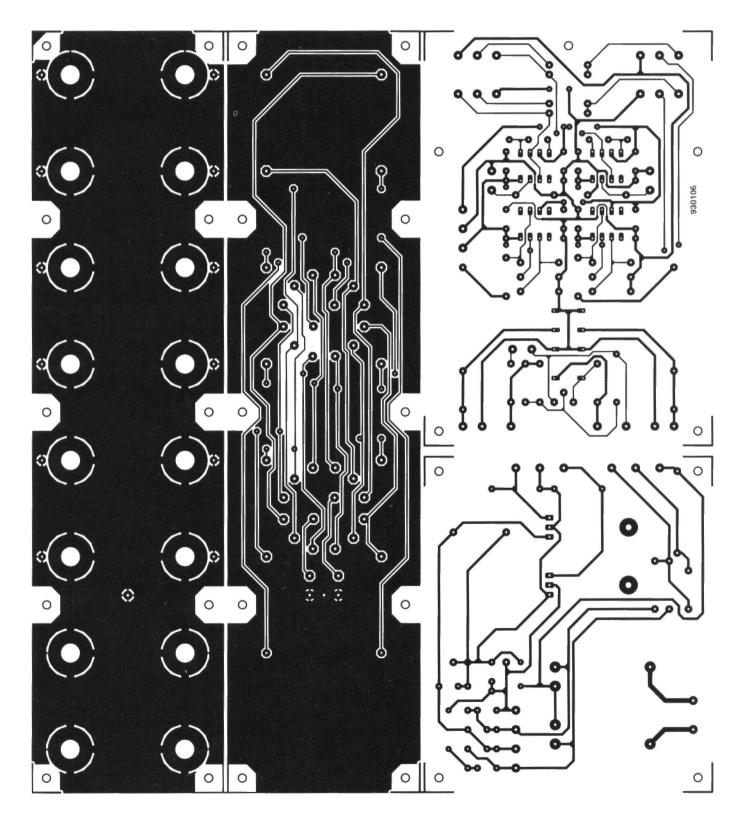


Fig. 5 (b). Printed circuit board (track layout) for the mini preamplifier.

Parts list

Resistors:

 $R_1 \text{--} R_{12}, \; R_{15}, \; R_{16} = \; 100 \; \mathbf{k} \Omega$

 R_{13} , $R_{14} = 1 k\Omega$

 R_{17} , R_{19} , $R_{30} = 2.2 \text{ k}\Omega$

 R_{18} , $R_{20} = 680 \Omega$

 R_{21} , $R_{24} = 270 \text{ k}\Omega$

 R_{22} , $R_{25} = 221 \Omega$, 1%

 R_{23} , $R_{26} = 1 \text{ k}\Omega$, 1%

 R_{27} , $R_{28} = 100 \Omega$

 $R_{29} = 6.8 \text{ M}\Omega$

 $R_{31}=180\;\Omega$

Potentiometers:

 P_1 = 10 kΩ, linear, stereo

 P_2 = 10 kΩ, logarithmic, stereo

Capacitors:

 C_1 , $C_2 = 22 \text{ pF}$

 C_3 , $C_4 = 10 \mu F$, MKT (polytherephtalate)

 $C_5 = 4.7 \,\mu\text{F}, 63 \,\text{V}$

 $C_6 - C_{13} = 100 \text{ nF}$

 C_{14} , $C_{1\bar{5}} = 10 \,\mu\text{F}$, 25 V

 C_{16} , $C_{17} = 470 \,\mu$ F, $40 \,V$

 C_{18} , $C_{19} = 220 \text{ nF}$

 $C_{20} = 100 \,\mu\text{F}, 40 \,\text{V}$

 C_{21} - C_{24} = 47 nF, ceramic

Semiconductors:

 D_1 , $D_2 = 1N4148$

 $D_3 = LED$, 3 mm

 D_4 , $D_5 = 1N4003$

 $B_1 = B80C1500$

 $T_1 = BC517$

Integrated circuits:

 IC_1 - IC_4 = See text:

NE5534 (bipolar)

SSM2131 (FET)

SSM2134 (bipolar)

OP27 (bipolar);

OP37 (bipolar

OPA627 (FET)

OPA637 (FET)

LT1028 (bipolar)

LT1115 (bipolar)

TLE2027 (bipolar)

TLE2037 (bipolar)

AD743 (FET)

AD745 (FET)

LT1007 (bipolar)

LT1037 (bipolar)

LM627 (bipolar)

LM637 (bipolar)

 $IC_5 = 7815$

 $IC_6 = 7915$

Miscellaneous:

K₁–K₁₆ = phono socket for board mounting

 K_{17} = 2-way terminal block, pitch 7.5 mm S_1 , S_2 = 2-pole, 6-position rotary switch for board mounting

Re₁ = 12 V miniature relay with 2 changeover contacts for board mounting

 Tr_1 = mains transformer, secondary $2 \times 15 \text{ V}$, 3.3 VA

Enclosure as appropriate

Mains socket for panel mounting

Mains on/off siwtch

PCB Ref. 930106 (see p. 70) Front panel foil (Not available ready made)

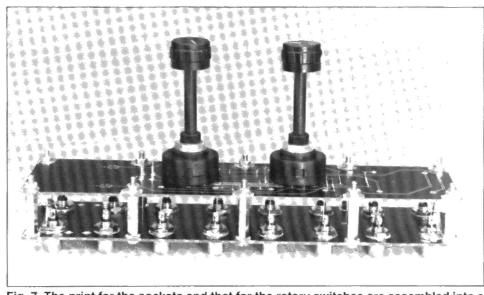


Fig. 7. The print for the sockets and that for the rotary switches are assembled into a 'sandwich' with the aid of suitable spacers.

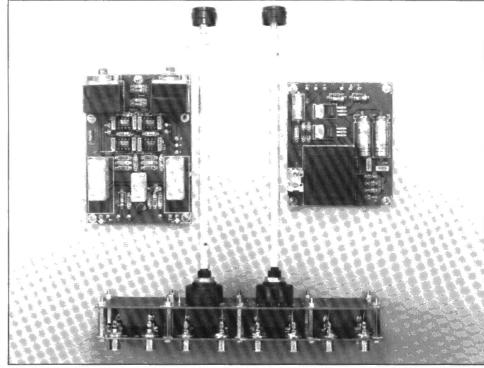
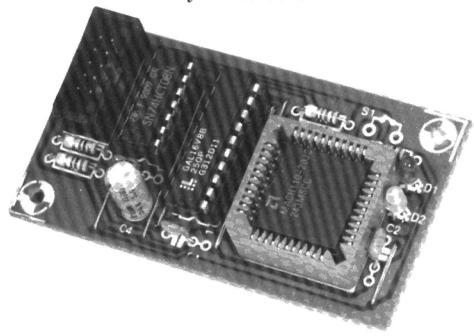


Fig. 8. The spindles of S_1 and S_2 must be extended to protrude through the front panel.

COPYBIT ELIMINATOR

By H.J. Schaake



This article describes an inexpensive and straightforward circuit for eliminating the copybit from a digital S/PDIF* audio signal. It enables any existing or future digital audio-signal source to be copied digitally time after time after time to any other digital audio recording system. In other words, with it one can copy (digitally) one's own musical work many times without degradation by the Serial Copy Management System—SCMS.

ver the past few years, more and more digital audio recording apparatus has become available: first, the DAT (Digital Audio Tape) recorder which was soon followed by DCC (Digital Compact Cassette) and Mini-Disc equipment. To meet the music industry's demand that copying of proprietary recordings (tapes, CDs, etc) should be difficult (in view of the menace of pirate copying), manufacturers of commercial digital recording equipment build in their apparatus a subsystem that enables making a digital copy once only. No further digital copies can be made from that copy, only analogue ones. This copy inhibit system is called Serial Copy Management System (SCMS). The system works with the aid of a bit, called the copy prohibit bit, which is contained in the serial digital audio signal. This is, of course, an excellent protective measure for the music industry, but it creates difficulties when one wants to make digital copies of one's private work. It is interesting to note, by the way, that

most professional apparatus is not equipped with SCMS: such equipment thus makes unlimited digital copying possible.

It is clear that where the rights of the musical recording(s) are privately owned, there can be no objection to making as many digital copies as needed. For such cases, the circuit described may be built into the digital recorder to eliminate the copy prohibit bit.

The S/PDIF signal

The S/PDIF provides a serial single-line connection in one direction for transporting a digital stereo audio signal with associated sub-codes and error detection. The connection may be by coaxial or optical fibre cable.

Since it is a one-way serial connection and the receive circuit must 'know' where each bit begins and ends, the signal must contain a clock. As illustrated in **Fig. 1**, this is achieved by biphase mark encod-

WARNING. The circuit described in this article is intended solely for the recording, processing and copying of private musical work. The Editor and Publishers disclaim all responsibility for its use that infringes any copyright vested in commercial compact discs and (digital) cassettes.

ing of all data. A'l'is coded as a whole squarewave period (T = 1/bitrate) and a '0' as a half square-wave period (T = 2/bitrate). Typical of this method is that at each and every bit edge a change of level takes place. This means that a special phase-locked loop—PLL—circuit can derive a bitrate synchronous clock from the signal. At the same time, it is, of course, useful if the receive circuit knows what each bit represents. Is it a sub-code bit? And, if so, which? Or is it an audio bit? If so, is it an MSB, and LSB, or in between? To give answers to such questions, the biphase coding protocol is suitably annotated at the first four bits of every 32-bit subframe.

Figure 2 shows the format of a subframe. Bits 0–3 form a preamble that may have one of three different forms: X, Y or Z—see **Fig. 3**. An X-preamble is the beginning of subframe A and a Y-preamble the beginning of subframe B—see **Fig. 4**. Together, subframes A and B form a frame of which 192 are contained in a block. The start of a block is marked by making subframe A0 begin with a Z-preamble instead of the usual X-preamble,

Bits 8–27 are 20 audio bits with the LSB as first bit. Bits 4–7 are either auxiliary data such as speech or four additional audio bits. Bit 28 is a validity bit that indicates whether the audio sample in the subframe is suitable for conversion to an analogue audio signal. Bit 31 is used as an even-parity check, that is, a simple error detection. Bits 29 and 30 are components of the subcode data. The subcode is transmitted by one bit per frame in Channel A as well as in Channel B. The 192 bits transmitted in each block form a complete subcode block that is repeated every 192 frames.

Bit 29 is used as user data block. It has no fixed definition and may be used freely

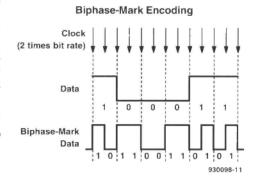
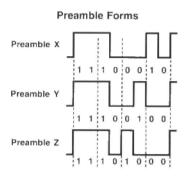


Fig. 1. Before their transmission, digital data are converted into a biphase format.

*Sony/Philips Digital Interface Format—the consumer version of the AES/EBU standard. This standard was devised by the American Audio Engineering Society and the European Broadcasting Union to define the signal format, electrical characteristics and connectors to be used for digital interfaces between professional audio products.[Editor]

Sub-frame Format Sub-frame Sub-frame Sub-frame 26 27 28 29 30 31 Preamble Aux Data LSB Audio Data MSB V U C P Validity User Data Channel Status Data Parity Bit 930098-12

Fig. 2. Format of a sub-frame



Preambles

	Biphase Patterns	Channel
Х	11100010 or 00011101	Ch. A
Υ	11100100 or 00011011	Ch. B
z	11101000 or 00010111	Ch. A & C.S. Block Start

930098-13

Fig. 3. The preamble of a sub-frame may have one of three forms which indicate the start of a channel and a block.

can be copied digitally once. However, once the copybit has been deactuated, the generation status bit plays no role.

The present circuit checks whether the copybit is set (logic 0) or not (logic 1). If it is 0, it is made 1; but if it is 1 already, nothing happens. It is of interest to know that the copybit needs to be altered only once. From then on, any digital recording can be copied again and again by anybody on any equipment.

Block schematic and timing diagram

The block schematic is given in **Fig. 6** and the timing diagram in **Fig. 7**. The S/PDIF signal is applied to RXIN. The input selector, operated by the ON/OFF or UNLK signal determines whether the S/PDIF signal is applied to the circuit or not. The clock derived from the S/PDIF signal by the mother equipment is set on to the FCK line. The clock frequency is twice the bit rate and shifts all biphase-coded bits into an 8-bit shift register. Those eight bits enable the

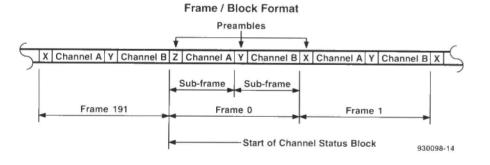


Fig. 4. A complete block is composed of 192 frames, each of which consists of a sub-frame A and a sub-frame B.

by the manufacturer for any application. Bit 30 is responsible for the channel status block. Note that channel status blocks A and B are identical.

The S/PDIF signal has a channel status block with consumer format: **Fig. 5** shows what the bits represent. For the present purposes only bit 2 of byte 0, the copybit, is of importance. Strictly speaking, so is bit 7 of byte 1, since this indicates the generation status. It is used to ensure that a private analogue recording on DAT

preamble detector to identify all X-, Y- and Z-preambles. As soon as preamble Z (QZ) is detected, the preamble counter is reset and two Y-preambles (QY) and two X-preambles (QX) are counted down, because the copybit is located in bit 30 of subframes 2A and 2B. Having arrived at subframe 2A, the preamble counter starts the bit counter by making the BCE signal logic high. Thereupon, the bit counter counts 52 clock periods and then makes the Copy Control Bit (CCB) high for one clock

period. A clock period later, the Parity Control Bit (PCB) is made high for one clock period in an identical manner. Since the copybit is contained in both channels, the CCB and the PCB in subframe 2B are also made high for one clock period in the manner described. Note that the CCB is high during the 'second half' of the copybit, whereas the PCB is high during the 'first half' of the parity bit. The exact location of the copybit in both Channel A and Channel B is now known. The function of the CCB and the PCB will be reverted to later.

Register I functions as a D-type bistable with inverted input and delays the S/PDIF signal by one clock period. If the output of Register 1 is denoted DEL, then in Boolean algebra:

DEL = SPDIFIN>

Register 2 also functions as a D-type bistable but with selective logic at the D input. Whether the copybit is set or not may be ascertained from input signals SPDIFIN, CCB and DEL. In Boolean algebra:

NCA = SPDIFIN · DEL · CCB + SPDIFIN · DEL > · CCB

Remember: the copybit is set when it is 0 (logic low) and a 0 coded in biphase results in a half period of a rectangular waveform with $T=2/\mathrm{bit}$ rate. The FCK clock frequency amounts to twice the bit rate. For example, in the top signal, SPDIFIN, in **Fig. 8**, Case 10(A), it is clear that the copybit (indicated by C) has not been set because its first half is low and the second half is high. In other words, it is a whole period of a rectangular waveform with $T=1/\mathrm{bit}$ rate and that corresponds to 1 (logic high).

As mentioned before, the CCB is high during the second half of the copybit. At that instant, DEL represents the inverted level of the first half and S/PDIF the second half. The first half is compared with the second half of the biphase-coded copybit: since the halves are not identical, output NCA of Register 2 becomes high a clock period later. NCA being high means that the copybit was not set.

The block Port in **Fig. 6** is a port without a register function. It is the last and most important link which ensures that the copybit is cleared if it was set: the parity bit is then also corrected. **Figure 8** shows all possible combinations of the biphase coded copybit/parity bit section that may occur in the SPDIFIN input signal, and the result at the Port output SPDIFOUT. The combinatorial function that arranges this is in Boolean algebra:

SPDIFOUT = SPDIFIN · CCB> · PCB + DEL · CCB + DEL> · PCB · NCA>

+ SPDIFIN · PCB · NCA

From a design point of view, it would be neater if Port were a register function, because theoretically glitches may arise during the active edges of the clock in the middle of the copybit and parity bit of each subframe 2A and 2B. In the prototype, no glitches were detected. Even if they had been, they would not have mattered much, because the S/PDIF receive circuit reacts to the signal between two active FCK edges, since that is taken to be more stable.

The SPDIFOUT signal from which the copybit has been eliminated is applied via the output selector to RXOU, from where it is passed directly to the S/PDIF input of a DCC or DAT recorder.

Since there is no register in the entire S/PDIF path and the copybit eliminator board is built into the mother equipment (but see 'Building in' later on), there is no additional PLL required to derive the FCK signal. This arrangement saves a lot of circuitry. There is also no need for an additional power supply, because the power drain is so small that the mother equipment can supply it.

To guarantee sure starting of the receive PLL, an additional switch input has been provided: UNLK. This provides the RX PLL signal that is found in all equipment with an S/PDIF receive circuit. It indicates whether the PLL generates a bit rate synchronous clock. If this is not so, the UNLK

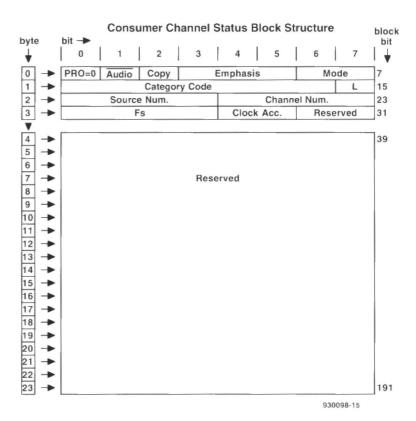


Fig. 5. The significance of the bits in the data block.

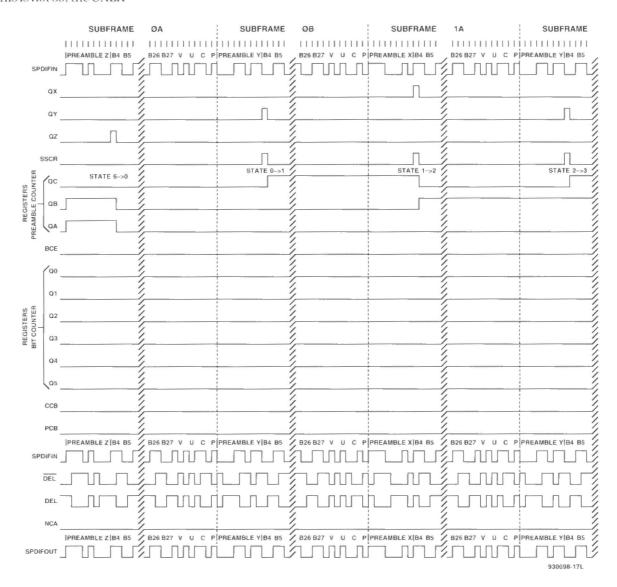


Fig. 7. This extensive timing diagram clarifies the

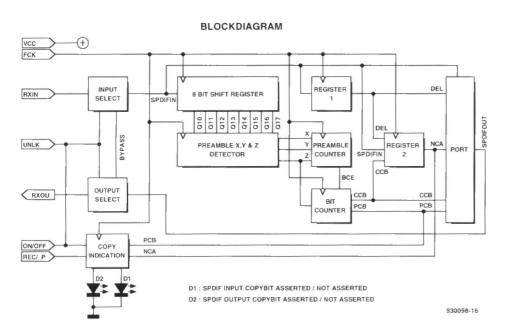


Fig. 6. Block diagram of the copybit eliminator

signal is assumed to be low and the copybit eliminator is then temporarily by-passed. As soon as UNLK becomes high,

the PLL is locked. When signal ON OFF is low, the S/PDIF signal is applied to the eliminator and filtering commences

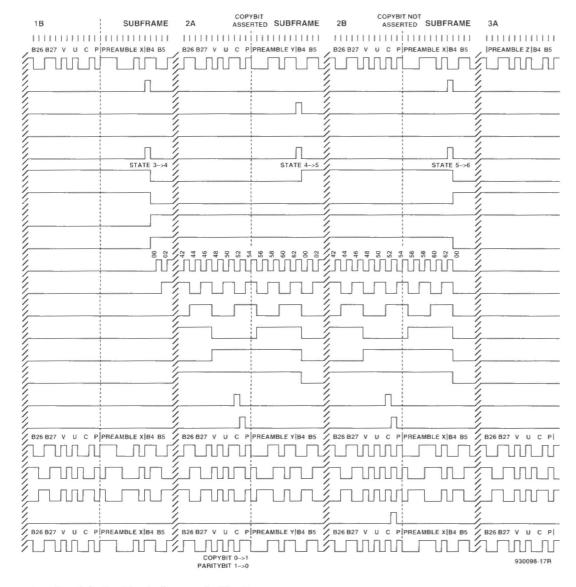
Copy indication is a copybit monitoring function which drives two LEDs. The input LED is on if a set copybit is present in the input signal. The output LED is on if a set copybit is present in the output signal. Normally, when the eliminator is operating, the input LED is on and the output LED is off.

The circuit

The LED indications are only true during recording and it is, therefore, necessary to take the record indication line from the mother equipment and connect this to REC/P. The LEDs can light only when REC/P is high.

All signals required for proper operation of the circuit pass via K_1 : the umbilical cord to the mother equipment.

Circuit IC $_1$ is a GAL/PAL Type 16V8, while IC $_2$ may for many readers be an unfamiliar logic building block: Type MACH110 from AMD. The MACHXXX is a new family whose members function somewhere between a PAL and an FPGA/EPLD/gate array. The MACH110 is roughly equivalent to $3\times$ a 22V10 GAL with an integral separately programmable connection matrix.



signal path in the block diagram in Fig. 6.

Fig. 8. All possible combinations of the copybit/parity bit part that may ocvcur in the SPDIFIN input signal and the result at Port output SPDIFOUT.

The LEDs are controlled by the four gates of a 74HCT08.

The eliminator can be switched off with S_1 , which connects pin 13 of IC $_{3d}$ to +5 V. When the switch is open, R_3 ensures that the eliminator is on automatically.

Construction

The eliminator is best built on the PCB in **Fig. 10**, which, together with the two programmed ICs (IC $_1$ and IC $_2$), is available ready made (see page 70). The MACH110 is housed in a PLCC case. One of the four corners of the IC is slightly flattened to show how the device should be located on the board. It should be mounted in a special socket to obviate any intricate soldering direct to the device.

 ${\rm K}_1$ is a 10-pin box header, so that the circuit can be conveniently connected to the appropriate points in the recorder via a length of flatcable.

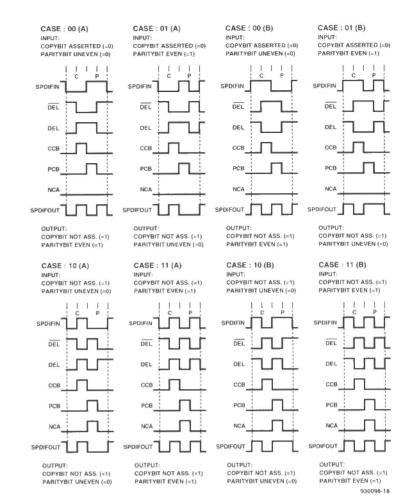
Finally, if use of S_1 is not foreseen, this switch may be omitted.

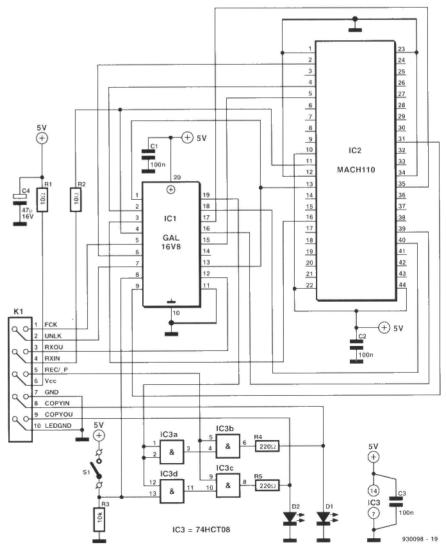
Building in

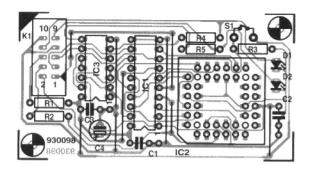
The eliminator is intended to be built into the mother equipment, for example, a DAT recorder. The necessary connections are made with a length of flatcable: those for five of the more popular recorders are given in Table 1. The following signals should be applied to the pins of K_1 as follows:

- 1. (FCK): $128f_{\rm S}$, that is, $128\times$ the sample frequency clock. If the eliminator does not function properly and all other connections are found to be all right, delay the FCK signal with the aid of a $150~\Omega$ resistor or invert it.
- 2. (UNLK): the PPL lock indication. This signal must be low when the PLL is locked. If it is high, invert it or do not use the signal, in which case the pin should be linked to earth.
- (RXOU): break the relevant track on the board behind the coaxial or optical S/PDIF input buffer. Connect the part of the track from the input buffer to RXIN and the other part to RXOU.
- 4. (RXIN): see instructions for pin 3.
- 5. (REC/P): the record indication signal; this is high when the mother equipment is recording.
- 6. (V_{cc}): the +5 V supply line from the mother equipment.
- 7. (GND): the digital earth of the mother equipment.
- 8, 9, 10. These are the LED connections

Fig. 9. Circuit diagram of the copybit eliminator.







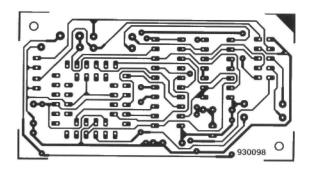


Fig. 10. The PCB for the copybit eliminator is small enough to be built into the mother equipment.

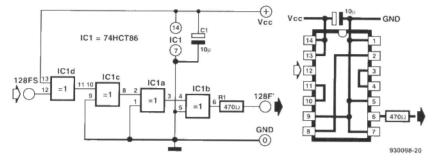


Fig. 11. Auxiliary circuit for use with Type XD-Z505 DAT recorder from JVC.

K ₁ pin no.	Signal in recorder	IC/pin in recorder	Remarks
Denon DTR-2000			
1	CKI0128	351/8	
2 3	DUNLOK	351/93	
	RX	351/23	
4		305/6	break track
5		not known	
6	+5 V	604/3	
7	D GND	604/2	
JVC XD-Z505			
1	128F'	401/13	
2	UNLOCK	401/62	
3	RX0	401/35	coaxial
3	RX1	401/34	optical
4	555	406/1	break track (coaxial)
4		406/13	break track (optical)
5	+5 V (D)	emitter Q21	
6	+5 V (D)	emitter Q21	mount heat sink on IC
7	G(D)	chassis	
JVC XD-Z1010			
1	128F	501/5	
2 3	UNLK	501/46	
	RX	501/51	
4		372/11	break track
5	***	not known	
6	5 V (D)	03/3	
7	G(D)	03/2	
Sony DTC 55ES & DTC 57ES			
1	F128	307/58	
2	UNLK	307/31	
2 3	RX	307/52	
4	RX	301/8	break track
5	Q2>	309/8	
6	+5 V	322/3	mount heat sink on IC
7	GND	chassis	

if D_1 and D_2 are desired to be located away from the eliminator board.

Most PLLs in an S/PDIF receive circuit generate a frequency that is twice or four times as high as the clock frequency. Fortunately, the generated frequency is scaled down synchronously, so it is always possible to find a clock of $128f_{\rm s}$. However, the S/PDIF-PLL of the JVC Type XD-Z505 DAT recorder generates a clock of $384f_{\rm s}$, which is scaled down by 3. Although this results in a clock of $128f_{\rm s}$, the leading edge of it is no longer at the centre (that is, the duty factor is not 50%). This is a small problem, however, which is easily remedied by delaying the clock with the aid of four HC gates as shown in **Fig. 11**.

Note that usually the warranty on the mother equipment is invalidated if any modification is carried out. It is for the constructor to decide whether the building in of the eliminator is worth that or whether to wait until the warranty has expired.

Parts list

Resistors:

 $\begin{aligned} R_1,\,R_2 &= 10\,\Omega \\ R_3 &= 10\,k\Omega \\ R_4,\,R_5 &= 220\,\Omega \end{aligned}$

Capacitors:

 C_1 – C_3 = 100 nF C_4 = 47 μ F, 16 V, radial

Semiconductors:

 D_1 = LED, 3 mm, red D_2 = LED, 3 mm, green

Integrated circuits:

 $IC_1 = 16V8$ (Ref. 6321, see p. 70) $IC_2 = MACH110$ (Ref. 6321, see p. 70)

 $IC_3 = 74HCT08$

Miscellaneous:

 $K_1 = 10$ -way straight box header $S_1 =$ switch with make contact PCB Ref. 930098 (see p. 70)

Table 1. Connections between K₁ and the relevant circuits in various mother equipment.

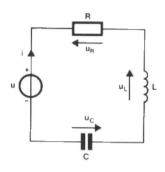
FIGURING IT OUT

PART 13 – SECOND-ORDER MODELS

By Owen Bishop

This series is intended to help you with the quantitative aspects of electronic design: predicting currents, voltage, waveforms, and other aspects of the behaviour of circuits. Our aim is to provide more than just a collection of rule-of-thumb formulas. We will explain the underlying electronic theory and, whenever appropriate, render some insights into the mathematics involved.

Last month we examined ways of using first-order differential equations to build circuit models. This month we extend the methods to include second-order equations. These allow us to model circuits of greater complexity, such as that in Fig. 110.



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Fig. 110

This includes resistive, inductive and capacitive elements. By Kirchhoff's Voltage Law:

$$u_L + u_R + u_C = u.$$

As we did last month, we use lower-case letters for quantities which are inherently variable in time and capitals for constants. Substituting equivalent expressions for the voltages, based on Eq. 26 of Part 4, Ohm's law, and Eq. 19 of Part 4:

$$L\frac{\mathrm{d}i}{\mathrm{d}t} + Ri + \frac{q}{C} = u$$

We will restrict the analysis to situations in which u is constant, hence du/dt = 0. Then, differentiating both sides of this equa-

$$L\frac{\mathrm{d}^2 i}{\mathrm{d}t^2} + R\frac{\mathrm{d}i}{\mathrm{d}t} + \frac{i}{C} = 0$$

In differentiating the third term, use q = it, and therefore dq/dt = i. The term d^2i/dt^2 makes this a second-order equation. Divide through

by L to make unity the coefficient of the first term:

$$\frac{d^2i}{dt^2} + \frac{R}{L} \frac{di}{dt} + \frac{1}{LC} \cdot i = 0$$
 [Eq. 94] If D is zero, the roots are both

Equation 94 models the circuit. It now remains to solve it and substitute actual values of R, Land C.

Auxiliary equation

For an equation of the form of Eq. 94, in which R, L and C are constants, there is an auxiliary equation of the form:

$$m^2 + fm + g = 0$$
, [Eq. 95]

in which f is the coefficient of di/dtand g is the coefficient of i. In Eq. 94, f = R/L and g = 1/LC. Solving Eq. 95 (a straightforward quadratic equation) for m is much easier than solving Eq. 94 for i. With values of f and g substituted in Eq. 95:

$$m^2 + \frac{R}{L}m + \frac{1}{LC} = 0$$
 [Eq. 96]

This is solvable by applying the well-known quadratic formula which, when applied to Eq. 95,

$$m = \frac{-f \pm \sqrt{f^2 - 4g}}{2}$$

The value of the expression f^2-4g (known as the**discriminant**, D)determines what kind of solution the equation has:

If D is positive, the equation has two real roots.

If D is zero, the equation has two equal roots.

If D is negative, the equation has two imaginary roots.

If D is positive, the two real roots are m_1 and m_2 and the solution to Eq. 94 is:

$$i = Ae^{m_1 t} + Be^{m_2 t}$$
 [Eq. 97]

m and the solution to Eq. 94 is:

$$i = Ae^{mt} + Bte^{mt}$$
 [Eq. 98]

If D is negative, we calculate $k = \sqrt{(-D/2)}$ and the solution is:

$$i = Ae^{-ft/2}\cos kt + Be^{-ft/2}\sin kt$$

[Eq. 99]

All three equations are general solutions (see Part 12) and have two arbitrary constants, A and B. Last month we had just one such constant and needed one border condition in order to find the particular solution. There are two constants, and we need two border conditions for second-order equations.

Worked example

Given $R = 500 \Omega$, L = 100 mH and $C = 2 \,\mu\text{F}$: $f = R/L = 500/100 \times 10^{-3}$ =5000; and $g = 1/LC = 1/100 \times 10^{-3}$ $\times 2 \times 10^{-6} = 5 \times 10^{6}$. From these values of f and g:

$$D = f^2 - 4g = 5000^2 - 20 \times 10^6$$

= 5×10^6 .

This is positive, so the equation has two real solutions:

$$m_1 = \frac{-f + \sqrt{D}}{2}$$

$$= \frac{-5000 + 2236}{2}$$

$$= -1382$$

$$m_2 = \frac{-f - \sqrt{D}}{2}$$
$$= \frac{-5000 - 2236}{2}$$
$$= -3618$$

Substituting in Eq. 97:

$$i = Ae^{-1382t} + Be^{-3618t}$$

[Eq. 100]

This is the general solution. We can apply this to any set of border conditions. We can imagine the voltage fluctuating, perhaps regularly, perhaps irregularly, causing a varying current in the circuit. Then, when t = 0, the voltage is suddenly held constant (Eq. 94). The models tells what happens after that. For this example, suppose that the current is 2 mA wen timing begins, or $i = 2 \times 10^{-3}$ when t = 0. Also assume a second border condition that the rate of change of current, di/dt, is 0.05 As⁻¹ when t = 0. With t equal to zero, e has zero index in both terms and so equals unity. Substituting the values for the first border condition in Eq. 100:

$$2 \times 10^{-3} = A + B$$

$$B = 0.002 - A$$

Substitute this value for B in Eq. 100:

$$i = A(e^{-1382t} - e^{-3618t}) + 0.002e^{-3618t}$$

[Eq. 101]

To incorporate the effect of the second border condition into the equation, we must first differentiate (see Part 5) Eq. 101 to obtain an equation for di/dt:

$$\frac{di}{dt} = A(-1382e^{-1382t} + 3618e^{-3618t}) - 7.236e^{-3618t}$$

[Eq. 102]

If di/dt = 0.05 when t = 0:

0.05 = A(-1382 + 3618) - 7.236.

A = (0.05 + 7.236) / 2236=0.003258.

Substituting this in Eq. 101:

 $i = 0.003258(e^{-1382t} - e^{-3618t})$ $+0.002e^{-3618t}$

Rearranging terms gives:

 $i = 0.003258e^{-1382t}$ $-0.001258e^{-3618t}$

[Eq. 103] This is the particular solution and Fig. 111 shows its graph. It shows that at t = 0 the current is 2 mA, as specified. The increase of current when t = 0 is too small to show on this graph. The tangent to the curve at this point would slope up to the right by only 3.6°. This upward slope is almost instantly countered by the relatively strong damping effects of capacitance and inductance. By the end of the third millisecond, the current has been almost entirely damped out.

Figure 112 shows what happens if we keep the first border condition unchanged, but have the current increasing at 2 A s⁻¹, instead of at only 0.005 A s-1. Substituting di/dt in Eq. 102:

A = (2 + 7.236) / 2236 = 0.004131.

From Eq. 101:

 $i = 0.004131e^{-1382t}$ $-0.002131e^{-3618t}$

We have another particular solution, matching the new border conditions. Its graph (Fig. 112) shows current continuing to increase, to about 2.12 mA, before damping takes effect. From the equations we have established, we can calculate the current and the rate of change of current at any instant from t = 0 onwards. With this information, we can go on to calculate the voltage across the components, and quantities such as the charge on the capacitor and the magnetic linkage of the inductor at any time.

Specifying later current

Border conditions need not be restricted to events occurring when t = 0. We can specify i or di/dt at any other instant after timing begins. It makes the equation slightly more complicated, because there is no simplification of the equations due to the index of e being zero. Let us try the same

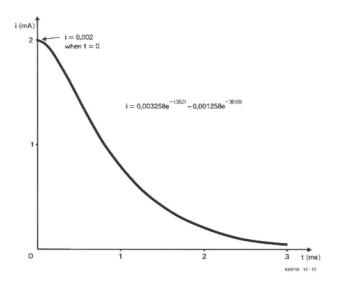


Fig. 111

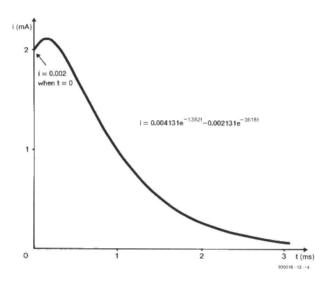


Fig. 112

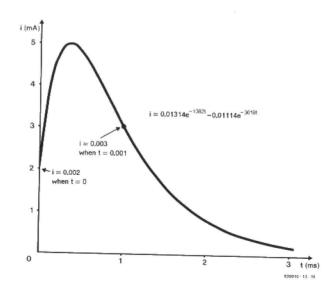


Fig. 113

der condition, but the second to a definite value in a specified border condition being that i = 0.003 when t = 0.001. We are

time. Since we have specified i, not di/dt, we go back to Eq. 101 circuit, with the same first bor-saying that the current increases and proceed from there. Substitute

the second border condition into this, which involves multiplying the indices by 0.001:

$$\begin{array}{c} 0.003 \! = \! A(\mathrm{e}^{-1.382} \! - \! \mathrm{e}^{-3.618}) \\ + 0.002 \mathrm{e}^{-3.618} \\ = \! 0.2242A \! + \! 5.3673 \! \times \! 10^{-5} \\ \therefore \quad A \! = \! 0.01314 \end{array}$$

Substituting the new value of A into Eq. 101:

$$i=0.01314(e^{-1382t}-e^{-3618t})$$

$$+0.002e^{-3618t}$$

$$=0.01314e^{-1382t}$$

$$-0.01114e^{-3618t}$$

Yet another solution, with the graph shown in Fig. 113. Current increases even further before damping takes effect.

Critical damping

The curves we have seen so far represent overdamping of the current. Current is reduced to zero fairly promptly. The model can be used also to investigate the circuit behaviour when it is critically damped. We reduce the capacitance slightly, to 1.6 µF, leaving R and L as before and, for comparison with Fig. 113, keep the same pair of border conditions.

With the new value for C, fremains unchanged, but g becomes 6.25×10^6 , and:

$$D = 5000^2 - 4 \times 6.25 \times 10^6 = 0$$
.

With a zero discriminant, the solution of the auxiliary equation

$$m = -f/2 = -5000/2 = -2500.$$

The general solution takes a different form (Eq. 98):

$$i = Ae^{-2500t} + Bte^{-2500t}$$

[Eq. 104]

Substituting the first border condition into this:

$$0.002 = A$$

Eq. 104 becomes:

$$i = 0.002e^{-2500t} + Bte^{-2500t}$$
.

Now substitute i = 0.003 and t = 0.001 into this:

$$0.003 = 0.002e^{-2.5} + 0.001Be^{-2.5}$$

$$B = 34.55$$
.

The particular solution is:

 $i = 0.002e^{-2500t} + 34.55te^{-2500t}$. [Eq. 105]

The graph in Fig. 114 shows current rising to a peak at 5.9 mA before being damped. The second border condition occurs on the way down.

Under-damping

This occurs when the discrimnant has a negative value. For example, let us reduce the capacitance drastically, to 10 nF. The f remains at 5000, but g becomes 10^9 and D becomes -3.975×10^9 . With a negative discriminant, we need to calculate k:

$$k = \sqrt{3.975 \times 10^9/2} = 44581$$

The general solution is given by Eq. 99:

$$i = Ae^{-2500t}\cos 44581t$$

+ $Be^{-2500t}\sin 44581t$

[Eq. 106]

Keeping to the same border conditions, applying the first condition to Eq. 106, and using the facts that $\cos 0 = 1$ and $\sin 0 = 0$:

$$0.002 = Ae^0 + 0$$

$$A = 0.002$$
.

Substituting this in Eq. 106, together with the values for t and i under the second border condition:

$$0.003 = 0.002e^{-2.5} \cos 4.4581$$

+ $Be^{-2.5} \sin 4.4581$
 $\therefore B = -0.03828$

This leads us to the particular solution:

$$i$$
=0.002e $^{-2500t}$ cos 44581 t
-0.03828e $^{-2500t}$ sin 44581 t

The graph of this equation has an interesting form—Fig. 115. It shows the current reversin g many times with gradually decreasing magnitude. Oscillations of this type are typical of an underdamped circuit. The oscillations take about 1.5 ms to die away.

Graphic calculator

A graph is an important aid to visualizing the behaviour of a model, and hence the behaviour of the circuit it is modelling. But plotting graphs is a tedious matter, particularly when equations contain several exponential terms. With over-dampled and critically-

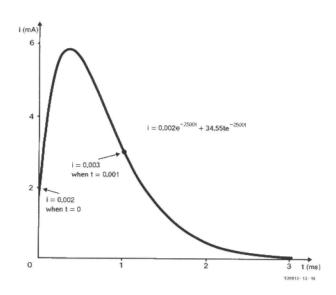


Fig. 114

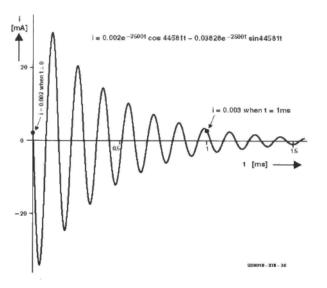


Fig. 115

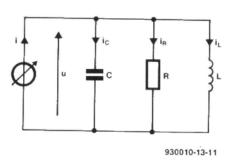


Fig. 116

damped circuits, it is possible to sketch the shape of the graph roughly after calculating half a dozen points. But the oscillations of an under-damped circuit often need 30 or more points to produce a reasonably representative curve.

A computer graphics package may save a lot of time: the illustrations to this article were

produced in this way. A graphic calculator produces results even more quickly. We used one when we were planning the values to use in the examples. To make graph plotting even quicker, program the calculator to accept variables, then to plot the graph.

The following is an example of a short program used on a graphic calculator to plot graphs

of equations of the same type as Eq. 103: 'EXPO1': "A":? \rightarrow A: "M1": ? \rightarrow C: "B":? \rightarrow B: "M2":? \rightarrow D: GRAPH Y=Ae-CX+Be-DX:. The program name is 'EXPO1'. The user is requested to key in values for A, m_1, B and m_2 . As soon as the final value has been keyed in, the graph is plotted according to the equation in the program.

A program can also include commands to set the ranges of t and i for the displayed graph. so that the curve fills the screen reasonably well. If the range command follows the input of variables, one or more of these variables can be used in the range commands. For example, the range for i can be set to run from -2 A to +2 A. It is also possible to include inputs to set the range of t directly from the program. For those who like to play around with models, adjusting the values to produce the required results. a graphic calculator is a valuable tool.

Parallel circuit

Figure 116 shows a circuit with resistance, capacitance and inductance in parallel. Building the model follows very much the same sequence as building the model of the series circuit. By KCL:

$$i_C + i_R + i_L = i.$$

Replacing the currents by equivalent expressions:

$$C\frac{\mathrm{d}u}{\mathrm{d}t} + \frac{u}{R} + \frac{N\varphi}{L} = i$$
 [Eq. 107]

The third term on the right is obtained by noting that $L=N\varphi/i$, as in Eq. 22, Part 5, where φ is the magnetic flux and N is the number of turns in the coil. Differentiating Eq. 107, and assuming that i is constant:

$$C\frac{\mathrm{d}^2 u}{\mathrm{d}t^2} + \frac{1}{R} \cdot \frac{\mathrm{d}u}{\mathrm{d}t} + \frac{u}{L} = 0$$

In obtaining the third term, $d\phi/dt = u/N$ (see Eq. 23, Part 5), so the term reduces to u/L. Dividing throughout by C gives the model equation:

$$\frac{\mathrm{d}^2 u}{\mathrm{d}t^2} + \frac{1}{RC} \cdot \frac{\mathrm{d}u}{\mathrm{d}t} + \frac{u}{LC} = 0$$

[Eq. 108]

The auxiliary equation is:

$$m^2 + m/RC + 1/LC = 0$$

in which f = 1/RC and g = 1/LC. With given values of R, C and L, the discriminant may be positive, zero or negative, yielding equations for u having the same

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form as Equations 97 to 99.

Here is an example of an underdamped circuit with $R = 1 \text{ k}\Omega$. C = 10 nF and L = 18 mH.

 $RC = 1 \times 10^{-5}$, so $f = 1/RC = 10^{5}$ and $f^2 = 1/(RC)^2 = 1 \times 10^{10}$.

 $LC = 1.8 \times 10^{-10}$, so 4g = 4/LC $= 2.222 \times 10^{10}$.

From these we find that $D = -1.222 \times 10^{10}$ and k = 78166. The general equation is:

 $u = Ae^{-50000t} \cos 78166t$

 $Be^{-50000t} \sin 78166t$

Now for some border conditions. When t = 0, u = -1; when t = 0.0001. u = -0.5. Using the first condition, remembering that $\cos 0 = 1$ and $\sin 0 = 0$:

-1 = A.

For the second condition:

 $-0.5 = -e^{-5}\cos 7.8166$ $+Be^{-5} \sin 7.8166$ B = -74.22.

The particular solution is:

 $u = -e^{-50000t} \cos 78166t$ $-74.22e^{-50000t}\sin 78166t$

The graph of this is shown in

Fig. 117. It begins with a massive 'kick' of up to -34 A. After a few swings of rapidly diminishing amplitude, the current is fully damped out in about 0.15 ms.

These examples show what can be done when we make certain simplifying assumptions about the model. If these assumptions are not valid, in particular, if we can not assume that voltage or current is constant, the equations are more difficult to differentiate and pass beyond the scope of this series, However, there are ways around this difficulty, as will be explained next month.

would like to thank the Casio Computer Company Ltd for their valuable assistance.

Test yourself

1. Find the particular equation

Acknowledgment. The author rent when t = 0.0008 s.

> 2. In another series circuit, $R = 5 \text{ k}\Omega$, $C = 22 \mu\text{F}$ and L = 0.5 H. When t = 0, i = 0.1and di/dt = 0.5. Find the particular solution for this circuit. Find the current when $t = 0.5 \,\mathrm{ms}$ and when $t = 100 \,\mathrm{ms}$. How long does the current take to fall to 0.01 A? (Plot a graph or solve the equation

0 0.05 t (ms) =-1 i = -0.5 - 5 when t = 0.0001 -10 -e^{-50000t} cos 78166t-74,22e^{-50000t} sin 78166t -15 -20 -25 -30

Fig. 117

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> which models a series circuit (Fig. 110) in which $R = 1 \text{ k}\Omega$, L = 200 mH and C = 100 nF, given the border conditions that i = -0.01 when t = 0, and i = +0.01 when t = 0.005. Is the circuit overdamped, critically damped or under-damped? Find the cur-

Answers to Test yourself (Part 12)

of di/dt by taking natural logs).

1. $q = 9e^{-1.418t} \times 10^{-4}$: (a): u = 1.45 V**(b)**: $i = 74.9 \, \mu A$.

2. 0.857 s.

3. 532 µA.

ELEKTOR ELECTRONICS FEBRUARY 1994

LIQUID CRYSTAL DISPLAYS

By M. Reichtomann

Although microprocessors are ideal for use in control circuits, they are not easy to communicate with. An LC display may help. Since most of such displays use an Hitachi controller, it is fairly easy to design a standard interface conform with the specification of the controller.

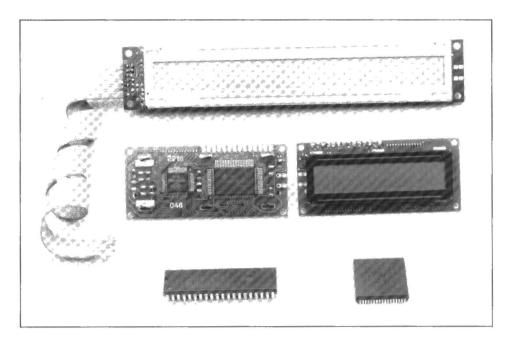
Figure 1 shows a display module integrated in a microprocessor bus as found in any MCS51 system. Many signals, such as those on the data bus and address line, and the supply voltage can be applied directly. Since the module puts a number of demands on the the timing of the R/W signal and the E input, control of the R/W line and the E input requires a small modification.

The signals of most importance for the LC module are shown in Fig. 2. It will be seen that signals RS and R/W must be active at least 140 ns before the E signal and that the E signal itself must be at least 450 ns long. Finally, during a write operation, RS, R/W and the signal on the data bus must remain active for not less than 20 ns after the E line has been deactuated.

As far as the microcontroller is concerned, data are usually taken from the databus at the edge of the R/W signal. This edge occurs within the time that the valid address as well as the correct data are available on the buses. The location of the enable signal (E) needed by the LC module can not be found in the signal diagram.

All timing signals of the processor have been derived directly from the system clock and are, therefore, multiples of the periods of the clock frequency used by the controller. It is, however, necessary in a number of cases to reduce these times by some nanoseconds in order to eliminate the delays in the various sub-circuits of the processor. **Figure 3** shows the timing of the signals on the MCS51 bus.

As shown in Fig. 1, the LC display is controlled by signals \overline{LCD} , \overline{RD} , \overline{WR} and A0. The only way of meeting the timing requirements of the display is by including address line A0 in the read/write signal for the LC module. This address line is made valid well before the R/\overline{W} edge appears on the processor bus. The consequence of this is that a different address must be chosen every time the module is read from or written to. During writing, the level at the R/\overline{W} input must be low: A0 is then also low. During reading, the level of R/\overline{W} must be high; A0 is then high also. Signal \overline{LCD} derives from the address decoder and this series



Liquid crystal displays are typified by the simplicity with which they can be controlled and accommodated in a circuit. This short article shows how these modules can be connected to the MCS51 microprocessor bus.

lects the display at auser-chosen address. Here, the basic address of the LCD module is $\rm D000_{H}$, so that the complete address is as follows:

Write command	Write	$D000_{H}$
Read command	Read	$D001_{\mathrm{H}}$
Write data	Write	$D002_{H}$
Read data	Read	$D003_{H}$.

Next, the length of the various signals as

a function of the processor clock can be determined. Remember the earlier stated limits.

clock (MHz)	$t_{\rm as}({\rm ns})$	$PW_{EH}\left(ns\right)$	$t_{\rm H}({\rm ns})$
8	325	650	75
10	250	500	50
12	200	400	33.3
16	138	275	12.5

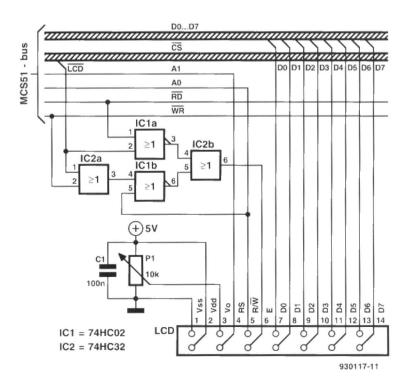


Fig. 1. Integrating an LCD module into an MCS51 system





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Up to a clock frequency of 10.9 MHz, everything works out all right, but at higher ones matters go awry. For such higher clock frequencies, the only solution is to connect

the display to an I/O port. Depending on the chosen mode (4 or 8 bits), seven or 11 data lines are then required.

Finally, the control voltage required for

setting the contrast is applied to the display via P_1 . In most cases, a control range of 0–5 V will be found more than adequate. END

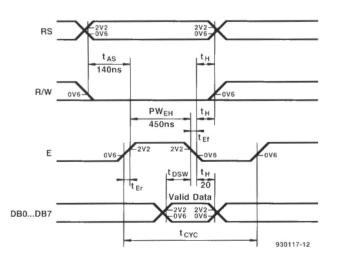


Fig. 2. The LCVD module puts certain demands on the timing.

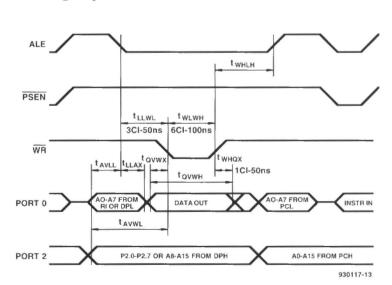


Fig. 3. Timing diagram of the MCS51 bus.

BUILDING YOUR OWN TOROID CORE INDUCTORS AND RF TRANSFORMERS

By Joseph J. Carr

A lot of electronic construction projects intended for hobbyists and amateur radio operators call for inductors or radio frequency (RF) transformers wound on toroidal cores. A toroid is a doughnut shaped object, i.e. a short, flat cylinder (often with rounded edges) that has a hole in the centre (see Fig. 1). The toroidal shape is desirable for inductors

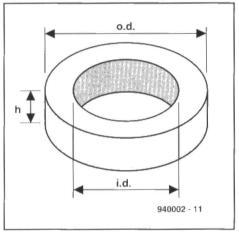


Fig. 1. The toroid coil form.

because it permits a relatively high inductance value with few turns of wire by virtue of the core's permeability (µ), and, perhaps most important, the geometry of the core makes the coil self-shielding. That latter attribute makes the toroid inductor easier to use in practical RF circuits. Regular solenoid-wound cylindrical inductors have a magnetic field that goes outside the immediate vicinity of the windings, and can thus intersect nearby inductors and other objects. Unintentional inductive coupling can cause a lot of serious problems in RF electronic circuits, so should be avoided wherever possible. The use of a toroidal shape factor, with its limited external magnetic field, makes it possible to mount the inductor close to other inductors (and other components) without too much undesired interaction.

Materials used In toroidal cores

Toroidal cores come in a variety of materials that are usually grouped into two general classes: **powdered iron** and

ferrites. These groups are further subdivided as discussed below.

Powdered iron materials.

The powdered iron cores come in two basic formulations: Carbonyl Irons and Hydrogen Reduced Irons. Carbonyl materials are well regarded for their temperature stability; they have relative permeability (u.) values that range from 1 to about 35. The Carbonyls offer very good 'Q' values to frequencies of 200 MHz. Carbonyls are used in high power applications, as well as in variable frequency oscillators and wherever temperature stability becomes important. However, note that no powdered iron material or ferrite is totally free of temperature variation, so oscillators using these cores must be temperature compensated for proper operation. The Hydrogen Reduced iron devices offer relative permeabilities up to 90, but are lower 'Q' than Carbonyl devices. They find their main usage in electromagnetic interference (EMI) filters. The powdered iron materials are the subject of Table 1.

Ferrite materials.

The name 'ferrite' implies that the material is iron-based, but that is not the case; ferrite materials are actually grouped into nickel-zinc and manganese-zinc types. The nickel-zinc material has a high volume resistivity and high Q over the range 0.50 to 100 MHz. The temperature stability is only moderate, however. The relative permeabilities of nickel-zinc materials are found in the range 125 to 850. The manganese-zinc materials have higher relative permeabilities than nickel-zinc, and are of the order of 850 to 5,000. Manganese-zinc materials offer high Q over the range 1 kHz to 1 MHz. They have low volume resistivity and moderate saturation flux density. These materials are used in switching power supplies from 20 to 100 KHz, and for EMI attenuation in the range 20 to 400 MHz. See Table 2 for additional information on ferrite materials.

Toroid core nomenclature

Although there are several different ways to designate toroidal cores, the one used by **Amidon Associates** [2216 East Gladwick, Dominguez Hills, CA, 90220,

USA; 310-763-5770 (voice) or 310-763-2250 (fax)] is perhaps that most commonly found in electronic hobbyist and

Material	$\mu_{\mathbf{r}}$	Comments
0	1	Used up to 200 MHz. Inductance varies with
Ī	20	method of winding. Made of Carbonyl C. Similar to Mixture No. 3 but is more stable, and has a higher vol-
2	10	ume resistivity. Made of Carbonyl E. High Q and good vol- ume resistivity over range of 1 to 30 MHz
3	35	Made of Carbonyl HP. Very good stability and good Q over range of 50 kHz to 500 kHz.
6	8	Made of Carbonyl SF. Is similar to mixture no. 2, but has higher Q over range 20 to 50 MHz.
10	6	Type W powdered iron. Good Q and high stability from 40 to 100 MHz.
12	3	Made of a synthetic oxide material. Good Q but only moderate stability over the range 50 to 100 MHz.
15	25	Made of Carbonyl GS6. Excellent stabil- ity and good Q over range 0.1 to 2 MHz. Recommended for AM BCB and VLF applica- tions.
17	3	Carbonyl material similar to mixture no. 12, but has greater temperature stability but lower Q than no. 12.
26	75	Made of Hydrogen Reduced Iron. Has very high permeabil- ity. Used in EMI filters and DC chokes.

Table 1. Powdered iron core materials.

amateur radio published projects. Although the units of measure are the English system used in the USA, Canada and formerly in UK, rather than SI units, their use with respect to toroids seems widespread. The type number for any given core will consist of three elements: xx-yy-zz. The 'xx' is a one or two letter designation of the general class of material, i.e. powdered iron (xx = 'T') or ferrite (xx = 'TF'). The 'yy' is an rounded off approximation of the outside diameter ('o.d.' in Fig. 1) of the core in inches; '37' indicates a 0.375-inch (9.53-mm) core, while '50' indicates a 0.50-inch (12.7-mm). The 'zz' indicates the type (mixture) of material. A mixture no. 2 powdered iron core of 0.50 inch diameter would be listed as a T-50-2 core. The cores are colour coded to assist in identification.

Inductance of toroidal coils

The inductance, L, of the toroidal core inductor is a function of the relative permeability of the core material, the number of turns, the inside diameter (i.d.) of the core, the outside diameter (o.d.) of the core, and the height (h) — see **Fig. 1**, and can be approximated by:

$$L = 0.011684 \, h \, N^2 \, \mu_{\rm r} \, \log_{10} \left(\frac{\rm o.d.}{\rm i.d.} \right)$$
 (H) [1]

This equation is rarely used directly, however, because toroid manufacturers provide a parameter called the $A_{\rm L}$ value which relates inductance per 100 or 1,000 turns of wire. Tables 3 and 4 show the $A_{\rm L}$ values of common ferrite and powdered iron cores, respectively. Table 5 shows some of the other properties of powdered iron cores.

Winding toroid inductors

There are two basic ways to wind a toroidal core inductor: close spaced winding and distributed winding. In distributed winding toroidal inductors the turns of wire that are wound on the toroidal core are spaced evenly around the circumference of the core, with the exception of a gap of at least 30° between the ends (see Fig. 2a). The gap ensures that stray capacitance is kept to a minimum. The winding covers only 270° of the core circumference. In close winding toroids (Fig. 2b) the turns are made such that adjacent turns of wire touch each other, or nearly so. This practice raises the stray capacitance of the winding, which affects the resonant frequency, but can be done in many cases with little or no ill effect (especially where the capacitance and resonant point shift are negligible). In general, close winding is used for inductors in narrow band tuned circuits, while distributed winding is used for broadband situations like con-

N-Z: Nickel-Zinc M-Z: Manganese-Zinc Material µ, Remarks 33 850 M-Z. Used over 1 kHz to 1 MHz for loopstick antenna rods. Low volume resistivity. 43 N-Z. Medium wave inductors and wideband transformers to 50 MHz. High attenuation over 30 to 400 MHz. High volume resistivity. 61 125 N-Z. High Q over 0.2 to 15 MHz. Moderate temperature stability. Used for wideband transformers to 200 MHz. 63 40 High Q over 15 to 25 MHz. Low permeability and high volume resistivity. 67 40 N-Z. High Q operation over 10 to 80 MHz. Relatively high flux density and good temperature stability. Is similar to Type 63, but has lower volume resistivity. Used in wideband transformers to 200 MHz. 68 20 N-Z. Excellent temperature stability and high Q over 80 to 180 MHz. High volume resistivity. 72 2000 High Q to 0.50 MHz, but used in EMI filters from 0.50 to 50 MHz. Low volume resistivity. J/75 5000 Used in pulse and wideband transformers from 1 kHz to 1 MHz, and in EMI filters from 0.50 to 20 MHz. Low volume resistivity and low core losses. 2000 0.001 to 1 MHz. Used 77 in wideband transformers and power converters, and in EMI and noise filters from 0.5 to 50 MHz. 3000 Is similar to Type 77 above, but offers a higher volume resistivity, higher initial permeability, and higher flux saturation density. Used for power converters and in EMI/noisefilters

Table 2. Ferrite materials.

from 0.50 to 50 MHz.

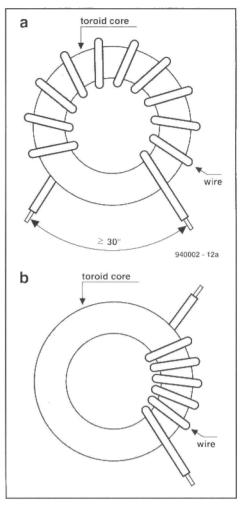


Fig. 2. Toroid winding styles: a) distributed; b) close wound.

ventional and BALUN RF transformers. The method of winding has a small effect on the final inductance of the coil. While this fact makes calculating the final inductance less predictable, it also provides a means of final adjustment of actual inductance in the circuit as-built.

Calculating the number of turns needed

As in all inductors, the number of turns of wire determines the inductance of the finished coil. In powdered iron cores the $A_{\rm L}$ rating of the core is used with fair confidence to predict the number of turns needed.

For powdered iron cores:

$$N = 100\sqrt{(L/A_{\rm L})}$$

Where:

N is the number of turns;

L is the inductance required in microhenrys (μH);

 $A_{\rm L}$ is an attribute of the core material and size ($\mu H/100$ turns).

Example

Find the number of turns of wire required to make a 6-µH inductance from a

T-50-2 (red) powdered iron core (A_L =49).

 $N = 100 \sqrt{(6 \mu \text{H}/49)} = 35 \text{ turns.}$

For ferrite cores:

$$N = 1000\sqrt{(L/A_{\rm L})}$$
 [3]

Where:

L is the inductance required in millihenrys (mH)

 A_L is an attribute of the core material and size (mH/1000 turns)

Example

How many turns are needed to wind a 200- μH inductor on a ferrite FT-50A-43 core ($A_{t_s}=570$ mH/1000 turns)? Note: 200 $\mu H=0.2$ mH.

$$N = 1000 \ \sqrt{(0.2/570)} = 18.7 \ \text{turns}$$

The number of turns calculation often comes out to a fraction of a turn. With the possible exception of 0.5 turns, the actual turns count should be rounded off to the nearest turn. It is possible to round off to the nearest half turn, but it is not as easy to implement in practice.

Building the toroidal device

The toroid core or transformer is usually wound with enamelled or formvar insulated wire. For low powered applications (receivers, variable frequency oscillators, etc.) the wire will usually be SWG22 through SWG36 (with SWG26 being very common). For high power applications, such as transmitters and RF power amplifiers, a heavier grade of wire is needed. For amateur high power applications, SWG14 or SWG12 wire is usually specified, although wire as large as SWG6 has been used in some commercial applications. Again, the wire is enamelled or formvar covered insulated wire. In the high power case it is likely that high voltages will exist. In high powered RF amplifiers, such as used by amateur radio operators in many countries, the potentials present across a 50-Ω circuit

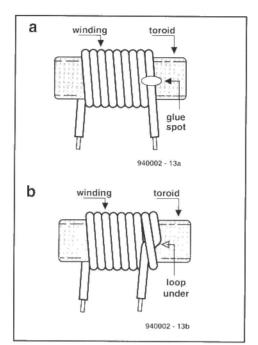


Fig. 3. Methods for fastening the wire on a toroid winding: a) glue spot; b) 'tuck under' method.

can reach hundreds of volts. In those cases, it is common practice to wrap the core with a glass-based tape such as **Scotch 27**.

High powered applications also require a large area toroid, rather than the small toroids that are practical at lower power levels. Cores in the FT-150-zz to FT-240-zz, or T-130-zz to T-500-zz are typically used. In some high powered cases several identical toroids are stacked together, and wrapped with tape to increase the power handling capacity. This method is used quite commonly in RF power amplifier and antenna tuning unit projects.

Binding the wires

It sometimes happens that the wires making up the toroidal inductor or transformer become loose. Some builders prefer to fasten the wire to the core using one of the two methods shown in **Fig. 3**. In **Fig. 3a** we see the use of a dab of glue, silicone adhesive, or the high voltage

scalant **Glyptol** (sometimes used in television receiver high voltage circuits) to anchor the end of the wire to the toroid core.

Other builders prefer the method shown in Fig. 3b. In this method, the end of the wire is looped underneath the first full turn and pulled taut. This method will effectively anchor the wire, but some say it creates an anomaly in the magnetic situation that may provoke interactions with nearby components. In my experience, that situation is not terribly likely, and I use the method regularly with no observed problems thus far.

When the final coil is ready, and both the turns count and spacing are adjusted to yield the required inductance, the turns can be anchored and the coil placed in service. A final sealing method is to coat the coil with a thin layer of clear lacquer, or 'Q-dope' (which product is intended by its manufacturer as an inductor sealant).

Mounting the toroidal core device

Toroids are sometimes a bit more difficult to mount than solenoid wound coils. but the rules that one must follow are not as strict. The reason for loosening of the mounting rules is that the toroid, when built correctly, is essentially self-shielding so less attention (not NO attention!) may be paid to components surrounding the inductor. In the solenoid wound coil, for example, the distance between adjacent coils and their orientation is important. Adjacent coils, unless well shielded. must be placed at right angles to each other to lessen the mutual coupling between the coils. However, toroidal inductors can be closer together and either co-planar or adjacent planar with respect to each other. While some spacing must be maintained between toroidal cores (the winding and core manufacture not being perfect), the required average distance can be less than for solenoid wound cores.

Mechanical stability of the mounting is always a consideration for any coil (indeed, any electronic component). For most benign environments, the core can be mounted directed to a printed circuit board (PCB) in the manner of Figs. 4a and 4b. In Fig. 4a, the toroidal inductor is mounted flat against the board; its leads are passed through holes in the board to solder pads underneath. The method of Fig. 4b places the toroid at right angles to the board, but still uses the leads soldered to copper pads on the PCB to anchor the coil. It is wise to use a small amount of RTV silicone sealant or glue to hold the coil to the board once it is found to work satisfactorily.

If the environment is less benign with respect to vibration levels, a method similar to **Fig. 4c** may be employed. Here the toroid is fastened to the PCB with a

Core	1	Ma	terial type			
size	43	61	63	72	75	-77
23	188	24.8	7.9	396	990	356
37	420	55.3	17.7	884	2210	796
50	523	68	22	1100	2750	990
50A	570	75	24	1200	2990	1080
50B	1140	150	48	2400		2160
82	557	73.3	22.8	1170	3020	1060
114	603	79.3	25.4	1270	3170	1140
114A	_	146		2340		
240	1249	173	53	3130	6845	3130

Table 3. Common ferrite core A, values.

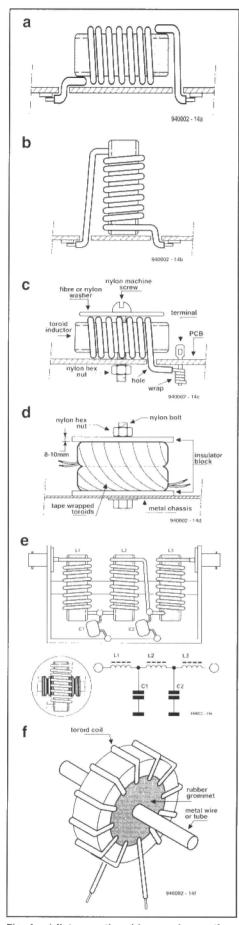


Fig. 4. a) flat mounting; b) on-end mounting; c) secured mounting (use nylon machine screws); d) mounting high power or high voltage toroidal inductors or transformers; e) suspending toroid inductors on a dowel; f) mounting method for a 'single turn primary' transformer in RF watt-meters or VSWR meters.

set of nylon machine screw and nut hardware, and a nylon or fibre washer. In high powered antenna tuning units it is common to see an arrangement similar to Fig. 4d. In this configuration, several toroidal cores are individually wrapped in glass tape, and then the entire assembly is wrapped as a unit with the same tape. This assembly is mounted between two insulators such as plastics, ceramic, or fibreboard, which are held together as a 'sandwich' by a nylon bolt and hex nut.

Figure 4e shows a method for suspending toroidal cores in a shielded enclosure. I have used this method to make five-element low pass filters (see inset) for use on my basement laboratory workbench. The toroidal inductors are mounted on a dowel which is made of some insulating material such as wood, plastic, plexiglass, Lexan or other synthetic material. If the dowel is sized correctly, the inductors will be a tight slip fit, and need no further anchoring. Otherwise, a small amount of glue or RTV silicone sealant can serve to stabilize the position of the inductor. Care must be observed against force fitting, however, in order to avoid fracturing the toroid core.

Some people use a pair of undersized rubber grommets over the dowel, one pressed against either side of the inductor (see inset to **Fig. 4e**). If the grommets are taut enough, no further action is needed. Otherwise, they can be glued to the rod.

A related mounting method is used to make current transformers in home made RF power meters (Fig. 4f). In this case a rubber grommet is fitted into the centre of the toroid, and a small brass or copper rod is passed through the centre hole of the grommet. The metal rod serves as a one-turn primary winding. A sample of the RF current flowing in the metal rod is magnetically coupled to the secondary winding on the toroid, where it can be either fed to an oscilloscope for display, or rectified, filtered and displayed on a d.c. current meter that is calibrated in watts or VSWR units.

Toroidal RF transformers

Both narrow band tuned and broadband RF transformers can be accommodated by toroidal powdered iron and ferrite cores. The schematic symbols used for transformers are shown in Fig. 5. These symbols are largely interchangeable, and are all seen from time to time. In Fig. 5a the two winding are shown adjacent to each other, but the core is shown along only one of them. This method is used to keep the drawing simple and does not imply in any way that the core does not affect one of the windings. The core may be represented either by one or more straight lines, as shown, or by dotted lines. The method shown in Fig. 5b is like the conventional transformer repre-

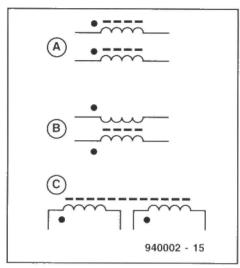


Fig. 5. Transformer symbols.

sentation in which the windings are juxtaposed opposite each other with the core between them. In **Fig. 5c** the core is extended and the two windings are along one side of the core bars.

In each of the transformer representations of Fig. 5 there are dots shown on the windings. These dots tell us the 'sense' of the winding, and represent the same end of the coils. Thus, the wires from two dotted ends are brought to the same location, and the two coils are wound in the same direction. Another way of looking at it is that if a third winding were used to excite the core from an RF source, the phase of the signals at the dot ends will be the same; the phase of the signal at the undotted ends will also be the same, but will be opposite that of the dotted ends.

The windings of the toroidal transformer can be spaced at different locations around the circumference of the toroid when the device is narrow band, but for wideband operation a **bifilar winding** scheme is used (**Fig. 6**). In this type of winding scheme, the wires, A and B, are held closely parallel to each other as they are wound around the core. When the job is finished, ends A1 and B1 will be at the same location, while A2 and B2 will be at another location on the toroid core.

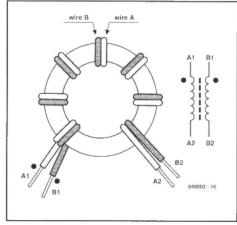


Fig. 6. Bifilar winding style.

Conventional transformers

One of the principal uses of transformers in RF circuits is impedance transformation. When the secondary winding of a transformer is connected to a load impedance, the impedance seen 'looking into' the primary will be a function of the load impedance and the turns ratio of the transformer (see **Fig. 6a**). The relationship is:

$$(N_{\rm p} / N_{\rm s}) = \sqrt{(Z_{\rm p} / Z_{\rm s})}$$
 [4]

With the relationship of Eq. [4] we can match source and load impedances in RF circuits.

Example

Assume that we have a 3 to 30 MHz transistor RF amplifier with a base input impedance of 4 Ω $(Z_{\rm s})$, and that transistor amplifier has to be matched to a 50- Ω source impedance $(Z_{\rm p})$, as shown in Fig. 7b. What turns ratio is needed to effect the impedance match? Let's calculate:

$$N_{\rm o} / N_{\rm s} = \sqrt{(50/3)} = 3.53:1$$
.

A general design rule for the value of inductance used in transformers is that the inductive reactance at the lowest frequency must be four times the impedance connected to that winding. In the case of the $50-\Omega$ primary of the transformer above, then, the inductive reactance of the primary winding should be $4\times50~\Omega$, or $200~\Omega$. The inductance should

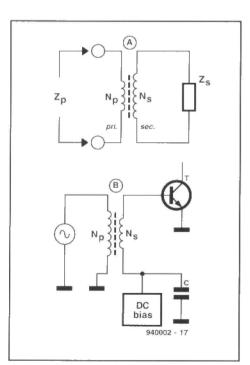


Fig. 7. a) generic transformer and load. Impedance seen looking into the primary is a function of the secondary impedance and the transformer turns ratio; b) Step-down impedance transformer coupling a 50 ohm input to an RF transistor.

Core		Core	material	type (mi	ix)				
size	26	3	15	1	2	6	10	12	0
12		60	50	48	20	17	12	7	3
16		61	55	44	22	19	13	8	3
20	_	90	65	52	27	22	16	10	3.5
37	275	120	90	80	40	30	25	15	4.9
50	320	175	135	100	49	40	31	18	6.4
68	420	195	180	115	57	47	32	21	7.5
94	590	248	200	160	84	70	58	32	10.6
130	785	350	250	200	110	96	MARKET AND ADDRESS OF THE PARTY		15
200	895	425		250	120	100	***************************************	_	*********

Table 4. Common powdered iron A, values.

be:

$$L = \frac{200\Omega \, 10^6}{2 \, \pi F}$$

$$L = \frac{200\Omega \, 10^6}{2 \, \pi \, 3.000.000} = 10.6 \, \mu \text{H}$$

Now that we know that a 10.6- μ H inductance is needed, we can select a toroidal core and calculate the number of turns needed. The T-50-2 (red) core covers the correct frequency range, and is of a size that is congenial to easy construction. The T-50-2 (red) core has an $A_{\rm L}$ value of 49, so the number of turns required:

$$N = 100 \sqrt{(10.6 \,\mu\text{H}/49)} = 47 \text{ turns}.$$

The number of turns in the secondary must be such that the 3.53:1 ratio is preserved when 47 turns are used in the primary:

$$N_s = 47 / 3.53 = 13.3 \text{ turns}.$$

If we wind the primary with 47 turns, and the secondary with 13 turns, then we will convert the 4- Ω transistor base impedance to the 50- Ω system's impedance.

Example

A Beverage Wave antenna is constructed for the AM broadcast band (530-1700 KHz). By virtue of its construction and installation, it exhibits a characteristic impedance $Z_{\rm p}$ of 600 Ω . What is the turns ratio required of a transformer at the feed end (**Fig. 8**) to match a 50- Ω receiver input impedance?

$$(N_s/N_{\rm p}) = \sqrt{(600\Omega/50\Omega)} = 3.46;1$$

The secondary requires an inductive reactance of $4\times600~\Omega$, or $2,400~\Omega$. To obtain this inductive reactance at the lowest frequency of operation requires an inductance of:

$$L = \frac{2,400\Omega \, 10^6}{2 \, \pi 530,000} = 721 \, \mu \text{H}$$

Checking a table of powdered iron toroid cores, it is found that the -15~(red/wht) mixture will operate over the 0.1 to

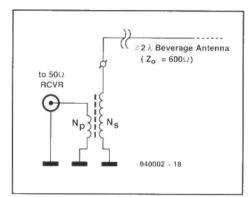


Fig. 8. Transformer coupling of 600-ohm Beverage antenna to a 50-ohm receiver input.

2 MHz region. Selecting a T-106-15 (red/wht) core gives us an $A_{\rm L}$ value of 345. The number of turns required to create an inductance of 721 μ H is:

$$L = 100 \sqrt{(721/345)} = 145 \text{ turns}$$

The primary winding must have:

$$N_{\rm p} = 145 / 3.46 = 42 \text{ turns}.$$

Winding the conventional transformer

When the windings of the conventional transformer are equal, i.e., where the turns ratio is 1:1, it is universal practice to wind the two coils in the bifilar manner discussed above (see Fig. 6). A special case of RF transformers called BALUN transformers (discussed below) uses this manner of winding exclusively. In cases where the windings are not equal, as is often the case in conventional transformers, there are three approaches to winding the coils. Figure 9a shows an RF transformer in which high impedance (high-Z) and low impedance (low-Z) windings are used. The two different styles of winding the coils are shown in Figs. 9b and 9c. The method shown in Fig. 9b keeps the primary and secondary separated on the core. This method is suitable for use in narrow bandwidth applications, for example in the tuning circuit of a radio receiver. The method in Fig. 9c intersperses the turns of the low-

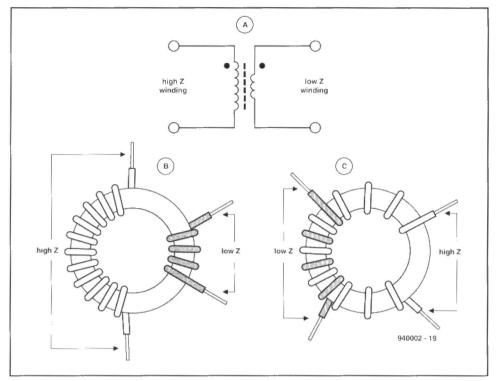


Fig. 9. a) two-winding RF transformer; b) separated windings; c) interleaved or bifilar winding.

Z winding over or among the windings of the high-Z winding. This method can be used for narrow band or relatively wideband applications. But if the transformer must be truly wideband, the best winding method is to wind the low-Z and high-Z coils in the bifilar manner as far as is needed to accommodate the low-Z winding. Starting from one point on the core, the wires are kept bifilar until the low-Z coil is completed, and then monofilar the rest of the way until the high-Z part is completed.

Connecting the conventional transformer in the circuit

A conventional RF transformer schematic symbol may have small dots, or some other device, to indicate the sense of the windings. They can also be used to determine the phasing of the signal transmitted through the transformer. In **Fig. 10a** the same ends of both windings are grounded, so the output signal is in phase with the input signal. In **Fig. 10b**, on the other hand, the opposite ends of the two windings are grounded, so the output signal is 180 degrees out of phase with the input signal.

Autotransformers

An **autotransformer** differs from conventional transformers in that there is only one winding, which is tapped to provide the two impedance levels needed. **Figure 11** shows the autotransformer in two different connection schemes. The connection scheme in **Fig. 11a** results in an in-phase output signal, while that of

Fig. 11b produces an out of phase signal across the load.

Winding the autotransformer proceeds along the same lines as for a straight coil, except that the two sections of the winding are broken at a point to create the tap. There are two schemes used in doing this job. In one method, the entire winding is one continuous piece of wire. A small loop is made at the tap, and made available to the rest of the circuit. The enameled insulation can be scrapped away and the wire tinned with solder. The other method, as shown in **Fig. 12**, breaks the two sections into two discrete windings, A-B and B-C. The connection

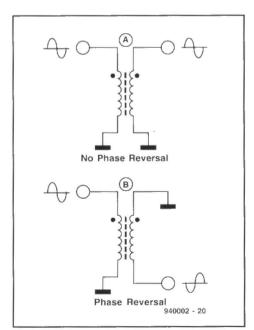


Fig. 10. Transformer connections: a) no phase reversal; b) phase reversal.

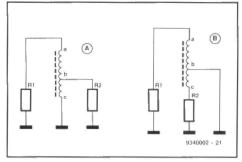


Fig. 11. Autotransformer connections: a) no phase reversal; b) phase reversal.

at the junction is soldered for electrical and mechanical integrity. It is very important that the two windings maintain the same sense. The A-B winding and B-C windings must be wound in the same direction. The starting turns of both sections in **Fig. 12** start in the same direction, as is needed to maintain the sense of the coils.

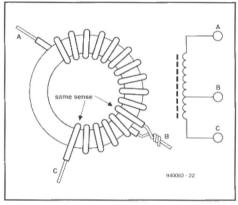


Fig. 12. Wiring detail for the autotransformer.

BALUNS, BAL-BALS and UN-UNS

There is a special category of RF transformer that are sometimes called transmission line transformers. These devices are available in several different configurations depending on the type of load at each winding and the impedance ratio. The balun transformer gets its name from BALanced-UNbalanced. which describes the relationship between the source and load types. In the balun, one load will be unbalanced with respect to ground (e.g. a coaxial cable from a standard 50-Ω transmitter output), while the other will be balanced with respect to ground (e.g. a dipole antenna). Amateur radio operators and SWLs often use 1:1 impedance ratio balun transformers at the feedpoint of dipole and other balanced antennas because it ensures that the pattern is a more nearly ideal bidirectional 'figure-8'. Other common balun devices are available in 4:1 impedance ratios. These devices can be used to match the feedpoint impedances of high impedance antennas such as the G5RV, the folded dipole, or the long wire.

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Figure 13 shows the two most common forms of voltage balun transformer. In the 1:1 impedance ratio version shown in Fig. 13a there are three bifilar windings on the same core, while in the 4:1 impedance ratio version of Fig. 13b there are two bifilar windings. In both cases, the sense of the windings are very important, and must be scrupulously observed.

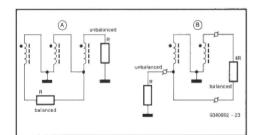


Fig. 13. a) 1:1 BALUN transformer; b) 4:1 BALUN transformer.

A pair of RF transformers are shown in Fig. 14. Although the transformer of Fig. 14a is usually called a 1:1 balun transformer in the literature, it is not technically in that category. Instead, it is an RF isolation transformer. It does serve the function of converting the balanced load to an unbalanced form that is compatible with the unbalanced input.

The transformer shown in **Fig. 14b** is a bal-bal in that it has a balanced load at both ends. The impedance ratio of this transformer is 4:1. It can be used to con-

Material type Colour code	$\mu_{\mathbf{r}}$	Frequency	(MHz)	
				S C LORD C
41 green	75	1 1 1 man 1		
3 grey	35	0.05 - 0.5		
15 red/white	25	0.1 - 2		
1 blue	20	0.5 - 5		
2 red	10	1 - 30		
6 yellow	8	10 - 90		y .
10 black	6	60 - 150		
12 green/white	3	100 - 200		
0 tan	1	150 - 300		
		a egite to the		

Table 5. Properties of powdered iron core types.

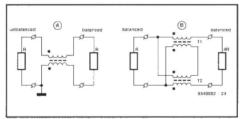


Fig. 14. a) RF isolation 'pseudo-BALUN' transformer; b) 4:1 current BAL-BAL transformer.

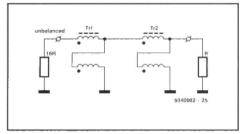


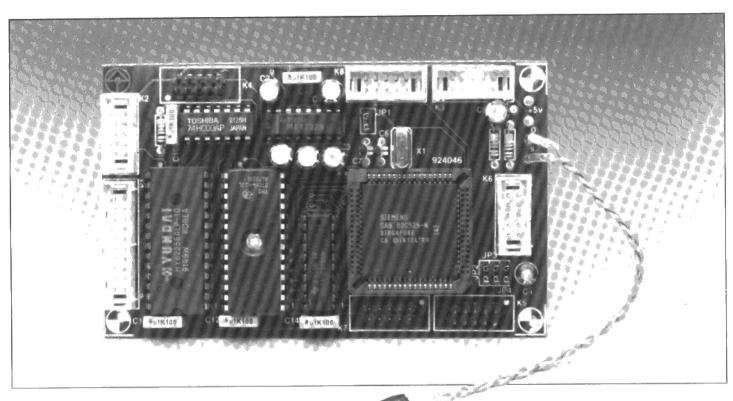
Fig. 15. 16:1 UN-UN RF transformer.

vert high impedance antenna feedpoints to a lower impedance while retaining the balanced feature. It is also occasionally used in RF power amplifier circuits. This circuit actually consists of two transformers connected together.

The circuit shown in **Fig. 15** is an unun transformer, i.e., it has an unbalanced load at both ends. This device is actually a pair of 4:1 transformers in cas-

cade, resulting in a 16:1 impedance ratio. One use for this transformer is to convert extremely low impedances to $50~\Omega$, as might be seen in RF power amplifiers or in vertical antennas in some installation situations. An example might be the 3 to $4\text{-}\Omega$ base impedance in a bipolar transistor RF power amplifier circuit. In order to match the $50\text{-}\Omega$ input impedance of the system, the 16:1 un-un transformer of **Fig. 15** can be used.

80C535 SINGLE-BOARD COMPUTER



Versatile and easy to build, the single-board computer described here is packed with goodies for the many microcontroller enthusiasts among you: ROM, RAM, a powerful 80C535 CPU, I/O ports, an ADC and an RS232 interface, all on an extremely compact board. The hardware is complemented by a monitor program in EPROM which allows you to use your PC to communicate with the 80C535. What's more, a short 80C535 programming course will be started next month.

Design by Dr. M. Ohsmann

S you can see from the above pho-Atograph, the printed circuit board designed for the 80C535 computer has been layed out with 'connectivity' in mind. All essential connections of the microcontroller are accessible via boxheaders fitted at the edges of the board. The computer is 'ready to go' with the EMON51 monitor EPROM (Ref. 1) fitted in the ROM socket, and compatible with fully 8051/80C32 programs. The 80C535 computer has an on-board 'RxD/TxD only' RS232 interface, which is easily connected to a PC running a communication program, or the V24 program downloader found on the 8051/8032 assembler course diskette. The RS232 interface on the present board has its own symmetrical voltage converter.

Apart from 32 KBytes of ROM and RAM, the board contains eight analogue signal inputs with a resolution of up to 10 bits. The ADC which reads the analogue signal levels is contained in the SAB80C535 microcontroller. The SAB80C535 from Siemens is an upgrade of the Intel 8051, to which it fully software compatible. Consequently, those of you who have already done some 8051 programming can 'upgrade' to the 80C535 without problems. Note, however, that the 80C535 has quite a few extra features with regard to the 8051. These fca-

MAIN SPECIFICATIONS

Hardware:

- Compact board (115 × 68 mm)
- Powerful 80C535 microcontroller
- 32 KByte CMOS static RAM
- 32 KByte EPROM
- RS232 interface
- All CPU port and control lines accessible via connectors
- External on/off control for on-board EPROM and RAM

Software:

- Compatible with 8051 assembler EASM51
- Compatible with 8051 system monitor EMON51
- Capable of stand alone RS232 operation
- Assembler course follow-up

tures are the subject of a short course on 80C535 hardware and software to be started in next month's issue of this magazine.

Lots of port lines

The circuit diagram of the 80C535 computer, **Fig. 1**, is basically a standard application of the 80C535 microcontroller. All port and control lines of the microcontroller, $1C_6$, are taken out to pins on connectors K_1 through K_8 . To avoid confusion between the pin

numbers and their actual positions, **Fig. 2** shows the pin arrangement of a 10-way boxheader as used on the board.

The circuit is **only** suitable for the CMOS SAB80**C**535 microcontroller, **not** for the standard N-MOS version 80535, which will be damaged 'beyond repair' when fitted because it has different functions for pins 4 and 37. Don't do it!

The address latch is formed by IC₄, a 74HC573, whose outputs supply the eight lower-order address bits A0

through A7, which are externally accessible via connector K₁. The readonly and read/write memory areas on the board are realized by a 32-KByte EPROM, IC₃, and a 32-KByte CMOS RAM, IC₁, respectively. The address decoding may strike you as unusual. A simple address decoder based on a four-fold NAND Type 74HC00 is used to divide the memory into four segments of 16 KByte each. Just like all processors in the 8051 series, the 80C535 is capable of addressing 64 KBytes of program memory (also

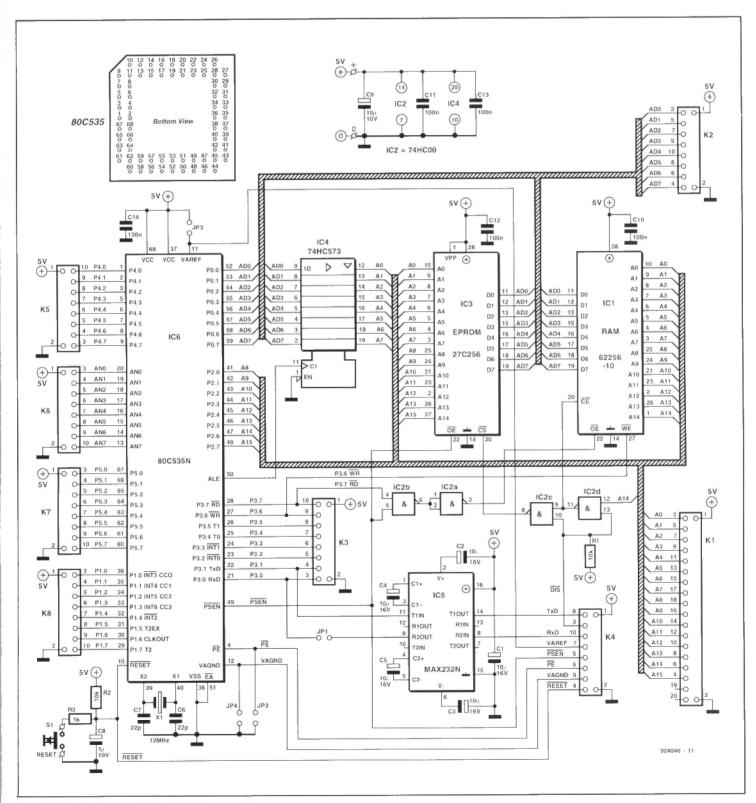


Fig. 1. Circuit diagram of the 80C535 computer.

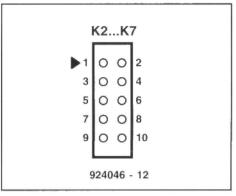


Fig. 2. Pin locations on the 10-way boxheaders used to hook up extension circuits to the 80C535 board.

80

6D

60

6

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.

0

-00

0

60 (8

called 'code' memory) and 64 Kbytes of data memory (also called 'external memory'). Access to the code memory is signalled by a low level on the PSEN line, while access to the data memory is marked by either RD or WR going low. The combination of logic signals in IC2 results in a physical address assignment as given in Table 1. This particular memory division was chosen to allow the EMON51 system monitor EPROM (Ref. 1) to be used without problems. EMON51 expects RAM from address 4000_H onwards.

The RAM and EPROM ICs on the board may be disabled by applying a low level to the DIS pin on connector K₄. If this pin is not connected, the 80C535 uses the on-board EPROM and RAM. The on/off control over the on-board memory is provided to enable the computer to be equipped with an external EEPROM, or a RAM with battery back-up. Alternatively, this feature may be used when controlling memory-mapped input/output de-

To make sure that the RS232 interface works with all PCs, the 80C535 board contains the well-known MAX232 RS232 serial line driver/receiver with an on-chip symmetrical voltage converter.

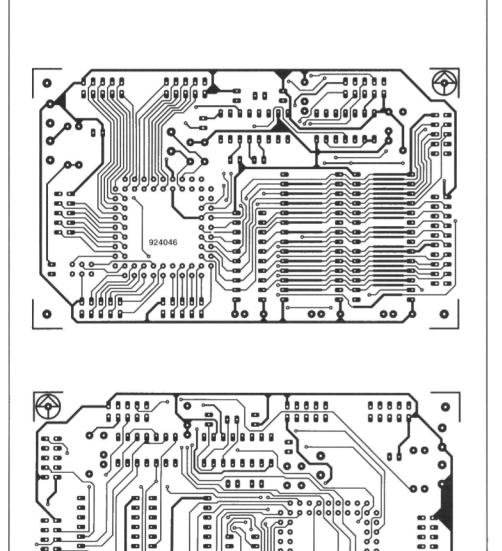
The microcontroller operates at a clock of 12 MHz to make sure that it can run all time-critical programs contained in the 8051 assembler language course.

Although the power-on RESET signal furnished by R2. R3 and C8 will be perfectly adequate for many extension and application circuits connected to the 80C535 computer, there may be applications, such as systems with a battery-backup RAM, where the timing of the reset signal is unsuitable. In these cases, it is suggested to omit C8 and R₂, and have the reset signal generated by a special IC with a watchdog, for example, the MAX690. If used, the external reset controller is connected to pin 4 of K_4 .

Jumpers

The board contains four jumpers, whose function is discussed below.

Jumper JP₁ allows the input of the serial interface contained in the 80C535 to be connected to the output of driver IC3. Obviously, this jumper has to be fitted if you want to communicate with the board via RS232 using the V24 program download utility on your PC. The jumper is omitted only if the board is connected to a computer or terminal which supplies TTL (0/5 V) signals, which are then fed directly to the P3.0 (RxD) input of the microprocessor. This line is also accessible



00

0 0

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8 8 8 8 8

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0000

0

6D (3)

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60 0

000

88888

99999

Code memory access:

0000H - 3FFFH EPROM 0000H - 3FFFH 4000H - 7FFFH RAM 0000H - 3FFFH 8000H - BFFFH EPROM 4000H - 7FFFH COOOH - FFFFH RAM 4000H - 7FFFH

Data memory access:

0000H - 3FFFH

4000H - 7FFFH RAM 0000H - 3FFFH

8000H - BFFFH

C000H - FFFFH RAM 4000H - 7FFFH

Fig. 3a. Track layouts of the double-sided through-plated printed circuit board.

Table 1. EPROM/RAM memory division.

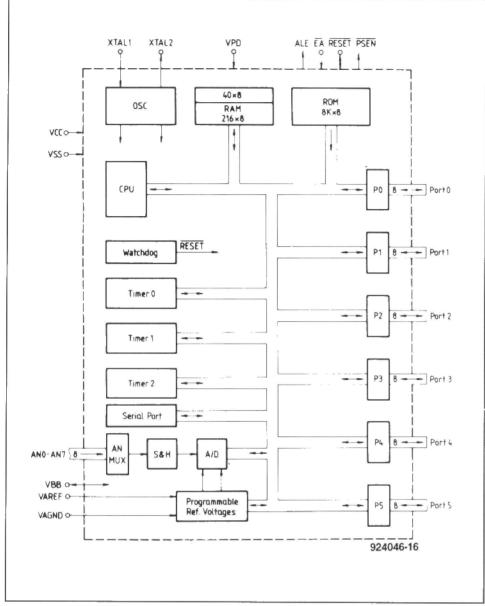


Fig. 4. SAB80C535 internal architecture (courtesy Siemens Components).

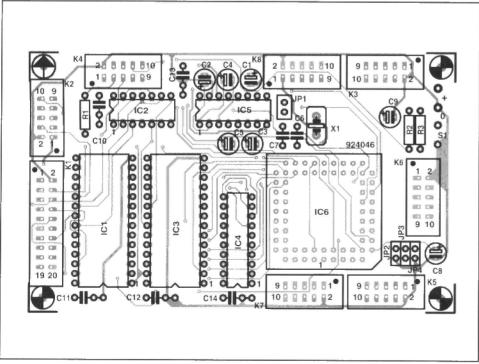


Fig. 3b. Component mounting plan.

80C535 HIGHLIGHTS

8051 software compatible
256-byte RAM
Three 16-bit timers
Eight analogue inputs
A-D converter with 8-bit resolution
(10-bit via software)
Baudrate generator for 4,800 or 9,600
baud at 12 MHz clock
Four 12-bit capture/compare registers
12 interrupts with four priority levels
Watchdog timer
Two extra 8-bit I/O ports
Power-down and idle modes

via pin 3 of connector K3.

The ADC contained in the 80C535 must be provided with a reference voltage, for which the VAREF and VAGND pins are available on the processor. If jumpers JP3 and JP4 are fitted, the reference is formed by the 5-V supply voltage, which will be sufficiently accurate for most simple applications. For measurements that require 'the last bit of digital precision' to be squeezed out it is recommended to use an external reference source. If this is used, omit jumpers JP3 and JP4, and connect the external reference to pins 7 and 9 on connector K4. As a matter of course, stay within the limits specified

COMPONENTS LIST

Resistors:

 $R1;R2 = 10k\Omega$

 $R3 = 1k\Omega$

Capacitors:

 $C1-C5 = 10\mu F 16V radial$

C6;C7 = 22pF

 $C8 = 1\mu F 10V radial$

 $C9 = 10\mu F 10V radial$

C10-C14 = 100nF

Semiconductors:

IC1 = 62256-10

IC2 = 74HC00

IC3 = 27C256 (EMON51 EPROM, order

code 1661; see page 70)

IC4 = 74HC573

IC5 = MAX232N (Maxim Inc.)

IC6 = SAB80C535 (Siemens

Components)

Miscellaneous:

K1 = 20-way boxheader

K2-K8 = 10-way boxheader

S1 = press-key, make contact

X1 = 12MHz quartz crystal

Printed circuit board 924046 (see page 70)

Jumper	Jumper fitted	Jumper not fitted
JP1	V24 to 80C535 RxD	external TTL RxD signal via K3 pin 3
JP2	Powerdown enabled	external, HIGH: Powerdown not allowed
JP3	VAREF to +5V	external reference via K3 pin 7
JP4	VAGND to GND	external analogue ground via K3 pin 9

Table 2. Jumper functions.

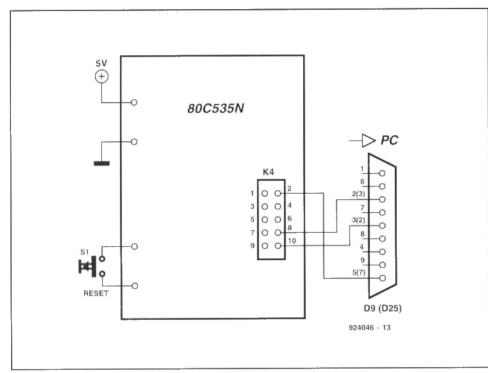


Fig. 5. Serial interface connection to the PC's RS232 port.

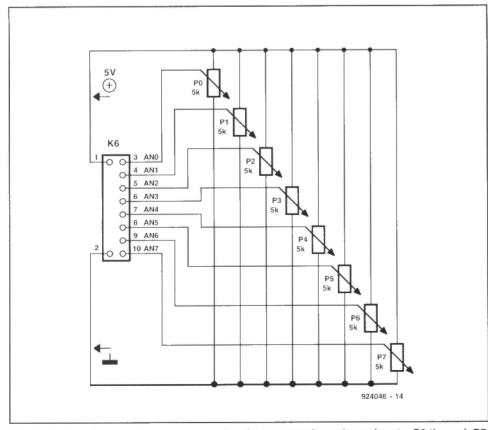


Fig. 6. Eight analogue voltages connected to the computer's analogue inputs, P0 through P7. Turn the pots to check out the operation of the test program given in Fig. 7.

for the external reference voltage. VAREF, for instance, must be within 5% of the supply voltage, while VAGND may not deviate more than 0.2 V from the ground potential. Also, the analogue input signal levels may not exceed the limits set by VAGND and VAREF by more than 0.2 V. This restriction is necessary to avoid excessive currents flowing in the input lines. In most cases, VAGND is best connected to the analogue ground of the external equipment, which is connected to the digital ground at a suitable point. VAREF is connected to the positive terminal of the external voltage source used.

Jumper JP₂, finally, controls the power-down and idle modes of the microcontroller. If JP₂ is fitted, the \overline{PE} input of the 80C535 is held low, which means that the power-down and idle modes may be controlled via software. This feature is effectively disabled if JP₂ is not fitted. Disabling the software power-down and idle modes may be required in no-break systems where the clock and timer must run at all times.

The jumper functions are summarized in **Table 2**.

Construction

The artwork for the printed circuit board is given in **Fig. 3**. The board is double-sided, through-plated, and available ready-made through the Readers Services. As you can see from the component overlay, the board is pretty densely populated, so take your time fitting the components, and solder **very** accurately using a low-power solder iron with a fine tip. It is recommended to use good quality IC sockets.

If it is intended to fit the controller board on to another board, the boxheaders may be replaced by doublerow pinheaders fitted at the solder side.

As already mentioned, C_8 and R_2 must be omitted if an external reset controller is used.

Compatible!

You can start working with the 80C535 board straight away if you have the EMON51 monitor EPROM fitted in position IC_3 . The link with the RS232 port on the PC is shown schematically in **Fig. 5**. The pin numbers in brackets refer to a 25-way sub-D connector. All jumpers are fitted on the 80C535 computer board.

First start V24 on the PC, then apply power to the 80C535 board. The system monitor should report with the welcome message on the PC after pressing reset key $\rm S_1$. If not, you have a faultfinding session ahead of you. Pin 50 of the 80C535 should supply a

```
***** EASM52 ASSEMBLER LISTING (B535F1) *****
LINE LOC
                    OBJ
                                                             SOURCE
                                                   8-channel A-D converter via V24
          poge
          0000
      3 0000
4 0000
5 0000
6 0000
                                                     define 80535 SFRs
                                                           EQU OFOH
                                              ACC EQU 0E0H
DPL EQU 083H
ADCON EQU 0D8H
ADDAT EQU 0D9H
DAPR EQU 0DAH
          0000
          0000
          0000
    10 0000
          0000
                                                    Calibration constants
          0000
          0000
                                                              EQU
                                                                               5000
                                                                                                 ; counter for calibration factor
                                                                           256
                                                                                                ; nominator of calibration factor
                                                     define internal RAM
          0000
                                                                                                ; start address in internal RAM
; 16 Bit measured AD_value
; p=pl : multiplier (16 bit value)
; q=ql : divisor (16 bit value)
; product ADval*p (32 bit value)
; result in mV=ADval*5000/256 (16 bit value)
          0000
                                               ADval
          0050
          0052
         0052
0054
0056
005A
005C
005C
4100
4103
4105
                                               q
PROD32
                                                                DS
                                                                DS
                                                               ORG 4100H ; program starts at 4100H
MOV DPTR,#TXTO ; start report
ACALL STXT ; transmit
MOV COMMAND,#ccGETC ; wait for ASCII Character
                    90 41 69
31 89
75 30 10
12 02 00
54 07
44 10
75 D8
75 DA 00
20 DC FD
E5 D9
F5 50
                                               MLP
                                                                LCALL MON
                                                                            A,#7
A,#00010000B
         410B
410D
410F
                                                                                                                   extract channel
                                                                                                                                                   number
                                                                ANL
                                                                                                              ; extract channel number; set start ADC bit; set AD control; start AD conversion from 0 to 5 Volt; wait until ready; fetch result; store as 16 bit number
                                                                ORL
                                                                            ADCON, A
DAPR, #0
    32 410F F5 D8
33 4111 75 DA
34 4114 20 DC
35 4117 E5 D9
36 4119 F5 50
37 411B 75 51
38 411E 90 13
                                                                             ADCON. 4. BSY
                                               BSY
                                                                             A, ADDAT
                                                                            ADval+0,A
ADval+1,#0
                                 0.0
                                                                MOV
                                                                                                               ; do output now
; p:=p1 (16 bit value)
                                               OUTPUT
                                                                              DPTR, #pl
                                 88
                                                                MOV
   38 411E 90 13
39 4121 85 82
40 4124 85 83
41 4127 78 52
42 4129 79 50
43 412B 75 30
44 412E 12 02
45 4131 86 56
46 4133 08
47 4134 86 57
88 4136 08
                                                                              p+0,DPL
p+1,DPH
R0,#p
R1,#ADvai
                                                                MOV
                                                                              COMMAND, #CCMUL ; compute ADval*p
MON
PROD32+0,@RO ; save to PROD32 (
                                52
                                                                                                               ; save to PROD32 (32 bit value)
                                                                MOV
INC
                                                                               PROD32+1.0RO
     48 4136 08
49 4137 86
                                                                INC
                                                                               PROD32+2,@RO
                     86 58
                                                                TNC
         4139
413A
413C
413F
4142
4145
4147
4149
                                                                               KU
PROD32+3,@RO
                    86 59
90 01 00
85 62 54
85 83 55
78 56
79 54
75 30 53
12 00
                                                                              DPTR,#q1
q+0,DPL
q+1,DPH
RG,#PROD32
                                                                                                               : q:-q1
                                                                              R1,#q
COMMAND,#ccDIV ; compute (ADval*p)/q (16 bit value)
MON
                                                                MOV
                                                                MON
                                                                LCALL
                                                                               Uval+0,@RO
                    86 5A
                                                                                                              ; store to Uval
          414F
                                                                MOV
    59 414F 86 5A
60 4151 08
61 4152 86 5B
62 4154 90 41 80
63 4157 31 89
64 4159 78 5A
65 4158 75 30 05
66 415E 12 02 00
67 4161 90 41 83
68 4164 31 89
                                                                INC
                                                                               Uval+1.0R0
                                                                                                               : transmit text
                                                                              DPTR,#TXT1 ; transmit text
STXT
R0,#CVal
COMMAND,#ccdR016; output Uval in mV decimal
MON
DPTR,#TXT2 ; transmit text
                                                                MOV
                                                                ACALL
                                                                              STXT
          4166 02 41 05 [2]
                                                                LJMP
                                                                              MT.P
     71 4169 DD DA 38
                                               TXTO
                                                                DB 13.10. '80C535 PROGRAM #1 ',13,10,0
                     30 43
33 35
50 52
47 52
                     4D 2D 23
31 20 0D
0A 00
55 3D 00
     72 4180 55
73 4183 20
                                                                               'U=',0
' mV',13,10,0
                     OD OA DO
     74 4189
     74 4189
75 4189
76 4189
77 4189
78 4189
79 4189
80 4189
                                                : Function codes for MONITOR calls
                                                                                                               ; transmit text
; transmit 16 bit value @RO decimal
; fetch ASCII character from V24
                                               CCSTXT
                                                                          002H
                                               ccdRo16 EQU
ccdRo16 EQU
ccGETC EQU
ccMUL EQU
ccDIV EQU
                                                                          002H
005H
010H
052H
053H
     82 4189
     83 4189
                                                COMMAND EQU
                                                                          030H
                                                                                                               ; MONITOR command storage location ; MONITOR entry address
83 4...
84 4189
85 4189
86 4189 75 30 02 [2] STXT
87 4186 02 02 00 [2] LJMP
88 418F
************ SYMBOL TABLE (28 symbols)
ACC :00E0 DPL :0082
ACC :00E0 DAPR :00DA
P :0052
-1100
                                                                          0200H
                                                                                                            ; set MONITOR command ; jump to MONITOR
                                                                MOV COMMAND. #CCSTXT
                                                                LJMP MON
                                                                                 DPH :0083
pl :1388
                                                                                                             ADCON :00D8
                                                                                                           q1 :0100
PROD32 :0056
BSY :4114
                                              p:0052
MAIN:4100
                                                                                 q:0054
MLP:4105
            Cva1
                      :005A
                                                                                                              TXT2 :4183
         OUTPUT
                      :411E
                                              TXT0 :4169
                                                                          TXT1 :4180
ccGETC :0010
                       +0002
                                       ccdR016
                                                        :0005
                                                                                                                         :0052
           ccDIV :0053
                                       COMMAND :0030
                                                                                 MON :0200
                                                                                                               STXT :4189
```

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clean ALE pulse, which can be verified with the aid of an oscilloscope. If you do not see a stable rectangular wave signal with TTL swing, the problem is most likely caused by a faulty or otherwise unsuitable quartz crystal. Exchange the crystal and try again.

Next, check all address and data lines for signals which do not have a TTL swing. If such a signal is found, or a more or less stable level of 2.5 V with respect to ground, you are probably faced with a pair of data or address lines which are short-circuited by excess solder.

If the monitor reports okay on the PC, you may download a chunk of object code. for instance, one of the example programs contained on the 8051 assembler course diskette. In the unlikely event of errors occurring, these are probably caused by a faulty RAM, IC₁.

All programming features of the 80C535 are supported by the 8051 assembler, EASM51, provided the 'new' special function registers of the 80C535 are properly defined using appropriate EQU statements in the assembler code.

A test application

The program listed in **Fig. 7** enables eight analogue voltages to be measured via the RS232 link with the PC. The desired channel number (between 0 and 7) is transmitted to the 80C535 board via the V24 utility (at 4,800 baud). The board returns the voltage level in decimal notation. The voltages to be measured must lie between 0 and +5 V, and are connected to boxheader K_6 (see **Fig. 6**).

The A-to-D conversion yields a digital value of 0 for an input voltage of 0 V, and 255, for an input voltage of 4.98 V. The actual signal voltage, *U*, is therefore computed from

 $U = \text{measured value} \times 5 \text{ V} / 256$ (V)

This is done by the program, which for convenience also handles the conversion into millivolts (mV). The arithmetic and number output subroutines contained in EMON51 are used for this purpose.

Reference:

1. 8051/8032 assembler course, *Elektor Electronics* February through November 1992. Course disk and monitor EPROM order code: 1661 (see page 70).

Fig. 7. Example program that makes use of the analogue-to-digital converter contained in the 80C535 microcontroller.

Solution to the Prize Electronic Crossword 2 by Matrix (December 1993)

Across

- 1. Common collector
- 9. Renumber
- 10. Stereo
- 12. Inst
- 13. Die-hard
- 14. FM
- 17. Gratis
- 18. Anathema
- 21. Filament
- 22. Litmus
- 24. RF
- 25. Off-days
- 27. Ecru
- 30. Ampere
- 31. Bachelor
- 33. Darlington pairs

Down

- 1. Carriage forward
- 2. Monostable
- 3. Ohms
- 4. Credit
- 5. LA
- 6. Ester
- 7. Tera
- 8. Root mean squares
- 11. Shunt
- 15. Film
- 16. Vermicelli
- 19. Trim
- 20. Anode
- 23. Dynamo
- 26. Fermi
- 28. Spar 29. Chip
- 32. MG

Winners of the construction kits are:

1st prize: P.B. Pinnell

2nd prize: S. Lewondowski

3rd/4th/5th prizes:

COMPONENT RATINGS

In resistor and capacitor values, decimal points and large numbers of zeros are avoided wherever possible. Small and large values are usually abbreviated as follows:

- $p (pico-) = 10^{-12}$ $n (nano-) = 10^{-9}$
- μ (micro-) = 10-6
- $m (milli-) = 10^{-3}$
- $k (kilo-) = 10^3$ $M \text{ (mega-)} = 10^6$
- $G (giga-) = 10^9$

Note that nano-farad (nF) is the international way of writing 1000 pF or 0.001 µF. Resistors are 1/3 watt, 5% metal film types unN.L. Cunningham P.S. Mainwaring

W. Sykes

Winners of the book prizes are:

A.C. Arnold

J. Cott

Mark Latham

Will Rimell

William Ritchie

All winners have been advised by letter.

LETTERS

Dear Editor-I know that a CGA card can relatively simply be connected to a TV receiver. Is this possible with a VGA card? I have not been able to find any literature on this.

J. Scott, Preston

The line and field frequencies used with a CGA card are similar to those used in a TV receiver, so that interfacing the two is, as you say, pretty straightforward. This is, unfortunately, not the case with a VGA card. The required interface would be guite complex. We have not published a design for this and, as far as we know, neither have other amateur publications. There are commercial units available, but these cost a couple of hundred pounds.

Dear Editor—I would like to get some more detailed information on the 'VHF/UHF tuner' (Oct/Nov 1993) as on the enclosed sheet of paper.

S. Svenson, Stockholm

Unfortunately, neither our Design Department nor the original (free-lance) designer have the time to go into your request. They feel, however, that most of the information you seek is already contained in the article. We trust that you will appreciate that with our busy agenda of getting our magazine out on time every month it is just impossible to enter into individual correspondence on a completed project. [Editor]

Dear Editor-I work in an environment where some equipment produces a fairly high steady frequency sound. I have read somewhere about 'anti sound' apparatus. Is such equipment available or can it be built simply? I have in mind to design such a unit with a microphone at one end and a loudspeaker at the other. Can you offer any suggestions?

F. Velsink, Holland

There does exist anti-sound equipment. but this is quite complex. The complexity arises from the fact that the sound to be eliminated must be monitored and analysed constantly. The anti-sound must be generated close to the source of the offending sound by a number of powerful loudspeakers. The frequency and level of the anti-sound must be adapted constantly to ensure that the sum of all the sounds is as small as feasible.

It is, therefore, not just a question of placing a microphone near the source of the offending signal and feed back the sound in anti-phase via a couple of loudspeakers. All the time, the system must be intelligent enough to detect how and to what degree the anti-sound must be changed to further reduce the offending sound or at least to keep it at a low level.

As far we know, there are no DIY kits for this type of equipment. [Editor]

less otherwise specified.

The direct working voltage of capacitors (other than electrolytic or tantalum types) is assumed to be ≥60 V. As a rule of thumb, a safe value is about 2× direct supply voltage.

Direct test voltages are measured with a $20 \text{ k}\Omega/V$ meter unless otherwise specified.

Mains (power line) voltages are not listed in the articles. It is assumed that our readers know what voltage is standard in their part of the

Readers in countries that use 60 Hz supplies, should note that our circuits are usually designed for 50 Hz. This will not normally cause problems, although if the mains frequency is used for synchronization, some modification may be required.

The international letter symbol ${}^{\iota}U$ is used for voltage instead of the ambiguous 'V'. The letter V is reserved for 'volts'.

The size of a metric bolt or screw is defined by the letter M followed by a number corresponding to the overall diameter of the thread in mm, the × sign and the length of the bolt or screw, also in mm. For instance, an M4×6 bolt has a thread diameter of 4 mm and a length of 6 mm. The overall diameter of the thread in the BA sizes is: 0 BA = 6.12 mm; 2 BA = 4.78 mm; 4 BA = 3.68 mm; 6 BA = 2.85 mm; 8 BA =2.25 mm.

